DOCUMENT RESUME

ED 196 547 PS 011 901

AUTHOR	Tseng, Rose Y. L., Comp.: And Others
TITLE	The Relationship Between Nutrition and Student Achievement, Behavior, and Health: A Review of the Literature.
INSTITUTION	California State Dept. of Education, Sacramento.: San Jose State Univ., Calif.
PUB DATE	80
NOTE	165p.
AVAILABLE FROM	Publications Sales, California State Department of Education, P.O. Box 271, Sacramento, CA 95802 ($4.00, plus 6% sales tax for California residents)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Academic Achievement: Animal Behavior: Body Weight: *Children: Cognitive Development: Dental Health: Hyperactivity: Literature Reviews: Lunch Programs: *Nutrition: Obesity: Physical Development: *Physical Health: *Student Behavior
IDENTIFIERS	Food Selection: Obesity: School Lunch Program

ABSTRACT

The punpose of this report is to review existing research concerned with the relationship of nutrition to student achievement, behavior and health. Information was obtained through searches of computerized data bases, review of journal citations, discussions and correspondence with nutrition personnel as well as reviews of materials available from a nutrition clearinghouse and one individuals's private bibliography. Each chapter of the report is an independent unit and includes separate conclusions and citations. After the introduction, Chapter Two presents the findings of studies of nutritional status that were conducted among children from various racial, age, sex and income groups. Chapter Three reviews research related to severe nutritional deficiencies. Chapter Four inspects studies of the effects of supplementary food programs. In Chapter Five influences on food selection and methods of improving food choices are discussed. Chapters Six, Seven and Eight focus on obesity, dental problems and hyperactivity, respectively. The relationship of malnutrition to (1) infection, (2) physical and mental development, (3) animal behavior, and (4) human behavior and achievement are explored in Chapters Nine through Twelve. Conclusions and recommendations are presented in Chapter Thirteen. The reviewed literature provides no evidence of severe, widespread malnutrition or hunger in the United States. (Author/RH)

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The Relationship Between Nutrition and Student Achievement, Behavior, and Health – A Review of the Literature

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CALIFORNIA STATE DEPARTMENT OF EDUCATION
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Sacramento, 1980

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$4.00

This document was published by the California State Department of Education, 721 Capitol Mall, Sacramento, CA 95814.

Printed by the Office of State Printing and
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Library Distribution Act
1980

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PREFACE

This study, undertaken by Dr. Rose Tseng, Joyce Mellon, and Karen Bammer of San Jose State University, is directed at the American child and his or her nutritional patterns. The Department of Education contracted with San Jose State University to meet the mandate in Senate Bill 654, Chapter 1003, Statutes of 1977. This mandate required that a statewide study be conducted of foods available to children in public schools and that a review be made of available research concerning the effects of nutrition on children. This study reviews, analyzes, and comments upon relationships between nutrition and student achievement, behavior, and health.

The project shows evidence of malnutrition through obesity, infectious disease, anemia, growth retardation, and dental disease. Interesting correlations can be drawn from the disguised manifestations of malnutrition: listlessness, apathy, and lack of exploratory activity. From the excellent research conducted, educators and nutritionists alike will see the value of the National School Lunch Program, Breakfast Program, and Special Milk Program as a supplement to (or possibly the only) meals provided to the child.

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CHAPTER 1

Introduction

To determine whether the nutritional status of American children is advancing or declining, their location on the nutritional spectrum must first be established. To accomplish this goal, the results from various large- and small-scale nutritional-status studies are summarized. These studies reveal the kinds and degree of nutrient deficiency or excess in the diet of American children and how these deficiencies or excesses are manifest in related health problems. Any evidences of change in achievement and behavior directly related to nutrition are also summarized. The aim of this work is to present a concise, easily understandable summary of the past decade of pertinent literature concerning nutritional status, health, behavior, and achievement of children. No attempt was made to include minute details of all research articles, but in the event the reader desires such scientific data, the all-inclusive list of references was carefully documented and included in this text.

Purpose of the Study

The purpose of this study is to review existing research, which has been conducted within California and elsewhere, regarding the relationship between nutrition and student achievement, behavior, and health. Each chapter is autonomous and includes separate conclusions and bibliographies. This document will form a foundation for further study to determine the adequacy of the California school lunch program.

Justification

California Senate Bill 654 (introduced by Senator Mills on March 24, 1977, and approved by the Legislature) requires the Department of Education to conduct a study of the nutritional value of the food served in public schools in the state of California. This bill requires that the Department of Education must report the outcome of this study to the Legislature by February 1, 1979.

The bill states that the foods available for sale in many school districts, including the school food program, do not always meet adequate nutritional standards and may contribute to the development of children's health problems, which may include dental disease, obesity, hyperactivity, and other chronically debilitating diseases. These conditions may have a lasting impact on a child's physical, intellectual, and social functioning.

Procedures of Data Collection

To retrieve citations of pertinent books, periodicals, and microfiche documents, these computerized data bases were searched: ERIC (through the San Jose Public Library) and AGRICOLA (through the National Agricultural Library). These files yielded abstracts of studies about nutrition published during the last ten years.

Other resources included a search of the literature available from the Nutrition Clearinghouse in Berkeley, California, and a review of citations from the 1976 and 1977 editions of the Index Medicus.

Other means of gathering data were: (1) personal discussions and correspondence conducted among personnel from local school lunch programs and the Office of Child Nutrition Services, Sacramento, California, and (2) a review of the private bibliography of George Briggs, Ph.D., University of California, Berkeley.

CHAPTER 2

Nutritional Status of Children

This chapter presents the findings of a number of nutritional status studies that were conducted among children from varied racial, age, and income groups.

Assessment of Status

"Nutriture is the state resulting from the balance between the supply of nutrients on the one hand and the expenditure of the organism on the other" (6). The antonym of nutriture is malnutrition, which includes both under- or overnutrition.

Only universal, accurate methods of assessment can determine the extent of malnutrition (14). The magnitude of the problem must first be defined, and then methods of alleviating the malnutrition must be outlined and implemented. One method of assessment has been called the A, B, C, D, and E of nutritional status assessment (26).

A. Anthropometric studies include analyses of height, weight, skin-fold thickness, and head circumference.

B. Biochemical studies include laboratory tests of blood and urine to determine any variations from normal.

C. Clinical studies include an evaluation of external bodily signs of nutrient abuse.

D. Dietary studies include food recalls and questionnaires.

E. Ecological studies include statistics concerning income, morbidity and mortality, geography, and culture.

Proper methods of collecting and evaluating data for A, B, C, D, and E studies have been well documented (8, 13, 17). Any status study which employs only one or two of the techniques listed cannot give a complete and accurate presentation of nutritional status. Incorporation of all these methods into a continuous-type study is the superior approach (16).

Review of Research Surveys Concerning Status

The following research surveys reveal the nutritional status of varied groups of children:

Mississippi Preschool Nutrition Survey (MPSNS) (20)

Since the preschool child is particularly vulnerable to malnutrition, many status surveys have been initiated in developing countries, where children form a large portion of the population. However, by the middle 1960s it became clear that little work had been done concerning the nutritional status of American children. With this need in mind, Owen and Kram conducted a pilot study in Mississippi between October 1967 and March 1968. Parents of 558 children between the ages of two and six years were questioned in their homes by trained dietary interviewers. These sample children were chosen from varied socioeconomic levels. Results showed that children from high-income families had dietary intakes higher in calories, calcium, iron, vitamin C, vitamin A; and the use of supplemental vitamins caused this same group to show higher values of thiamin and riboflavin. Data in Tables 1 through 3 show that some results of the study agree with earlier studies and indicate that poverty children are smaller in stature than average and appear to be more "at risk" nutritionally (20).

Nutritional Status of Preschool Children in the United States, 1968-1970 (21)

Armed with the results of the study cited above, G. M. Owen and his staff undertook a survey of preschool children in the United States. The study was to include a cross section sample of preschool children, not to ascertain the prevalence or severity of malnutrition but rather to derive results to be used as a basis for comparison of: other sample groups in this study, sample groups in studies by other investigators, and sample groups in future investigations. The investigation included approximately 3,500 children from one to six years old who were Warner (21) ranked according to socioeconomic status from I to IV (I indicating lowest socioeconomic status) and further subdivided by age, sex, and ethnic group. Trained interviewers collected dietary data, consisting of a two-day diet record, including recipes, brand names, exact amounts as determined by use of scales, and volume measures where applicable. Accuracy was maintained as much as possible. Dental, clinical, and laboratory examinations followed the dietary data collection process. Results were processed by computer. Standards of comparison, namely, Recommended Daily Allowances (RDA) and Food and Agriculture Organization (FAO) required amounts, were chosen previously for the pilot study and were used also in this study (21). Data in Table 4 show percentages of children with low dietary intakes in the four different socioeconomic groups (low meaning less than total RDA). Fewer children in the higher socioeconomic groups (III and IV) exhibited low dietary intakes of calories, protein, calcium, iron, vitamin A, thiamin, riboflavin, and vitamin C than the children in the lower socioeconomic groups (I and II).

Ten-State Nutrition Survey (TSNS) (28)

In 1967 Congress directed the Department of Health, Education, and Welfare to investigate the magnitude and location of malnutrition and any related health problems. The department, in turn, assigned the responsiblity to the nutrition program. This study, called the Ten-State Nutrition Survey, was directed at Washington, California, Texas, Louisiana, South Carolina, Kentucky, West Virginia, Michigan, Massachusetts, and New York (a separate survey of New York City was included). Emphasis was placed on the low-income segment of the population, as this was the group in which malnutrition was thought to be most common.

Table 1

Age, Income and Geographical Habitat of the Sample

Group	Subjects			Monthly per capita income	Urban	Rural
	Number	12-24 months Percent	25-72 months Percent		Percent	Percent
A	210	14	86	<$500	32	68
B	97	20	80	$500-1000	46	54
C	110	16	84	$1000-1500	41	59
D	135	12	88	>$1500	41	59

Source: (20)

Table 2

Average Daily Dietary Intakes

Group	Calories per kg	Protein gm/kg	Calcium mg	Iron mg	Vitamin A iu/kg	Thiamin mg/1000	Riboflavin mg/1000	Ascorbic Acid mg
A	80	3.0	541	8.1	250	41	0.7	0.9
B	85	3.2	625	7.3	210	42	0.6	0.9
C	93	3.7	765	8.6	256	51	0.6	1.0
D	101	3.8	783	8.8	224	55	0.5	0.9

Source: (20)

Table 3

Percentage of Children with Low Dietary Intakes

Nutrient	Group A percent	Groups B, C, and D Percent
Calories	44	24
Protein	6	3
Calcium	38	15
Iron	75	62
Vitamin A	7	2
Thiamin	0	2
Riboflavin	2	1
Ascorbic Acid	30	13

Source: (20)

Table 4

Percentage of Children with Low Daily Dietary Intakes

	Warner Rank			
	I	II	III	IV
Energy (kcal/kg)	34	19	15	15
Protein (gm/kg)	3	1	0	0
Calcium (mg)	21	9	8	5
Iron (mg)	55	49	52	50
Vitamin A (IU)	5	0	0	0
Thiamin (mg)	9	2	2	2
Riboflavin (mg)	8	1	1	1
Vitamin C (mg)	16	7	2	2

Source: (20)

The sample population chosen was first subdivided according to income ratio. The sample groups were rated simply as high- or low-income ratio states (Figure 1). Next, the samples were separated into ethnic groups and designated as white, black, or Spanish-American. Finally, the sample was further subdivided into age and sex groups (28). A comparison of the standard for evaluating intakes of children from one to six years of age from both the Ten-State Nutrition Survey (TSNS) and the Mississippi Preschool Nutrition Survey (MPSNS) with the standard requirements (RDA and FAO) is given in Table 5. Among the various age groups in the study, children from the ages of ten to sixteen years had the highest prevalence of unsatisfactory nutritional status, and the widespread extent of iron deficiency anemia was reaffirmed. Low intakes of vitamin A among the Mexican-American children were evidenced. While low levels of vitamin C did not appear to be a major problem, lower than normal vitamin C intakes appeared more often among males than females and seemed to increase with a child's age. Thiamin levels were adequate, whereas riboflavin intakes appeared to be low among young people regardless of ethnic group (28).

Can a conclusion be reached from the TSNS concerning the prevalence of malnutrition? The following quote from the American Academy of Pediatrics Committee Statement responds to this issue:

> Some degree of malnutrition does indeed exist in a substantial number of the American children studied in the survey. To a significant degree, malnutrition in children appears to be a consequence of both the quality of life and the economic status of the family. Present information should prompt the pediatrician and other physicians caring for children to become increasingly aware, informed, and concerned about nutritional problems in a population of growing individuals. While it is incumbent upon the physician to treat malnutrition in his patients, it must be noted that the limited approach entailed in assuming that the physician plays the only role in relieving malnutrition is not likely to succeed. Where malnutrition emerges as a consequence of impecunity, society as a whole must be involved in amelioration. (14: 1099)

The First Health and Nutrition Examination Survey (HANES), 1971-1972 (15)

Between May 1971 and June 1974 the First Health and Nutrition Examination Survey was conducted. A specific objective of this survey was to assess and observe the status of the American people over an extended period of time. Samples of various age groups representative of the population were selected. The nutrition section of the survey consisted of four parts:

1. Food frequency questionnaires and a twenty-four hour recall

2. Chemical tests of blood and urine samples

3. Examination for clinical signs of deficiency

4. Anthropometric measurements

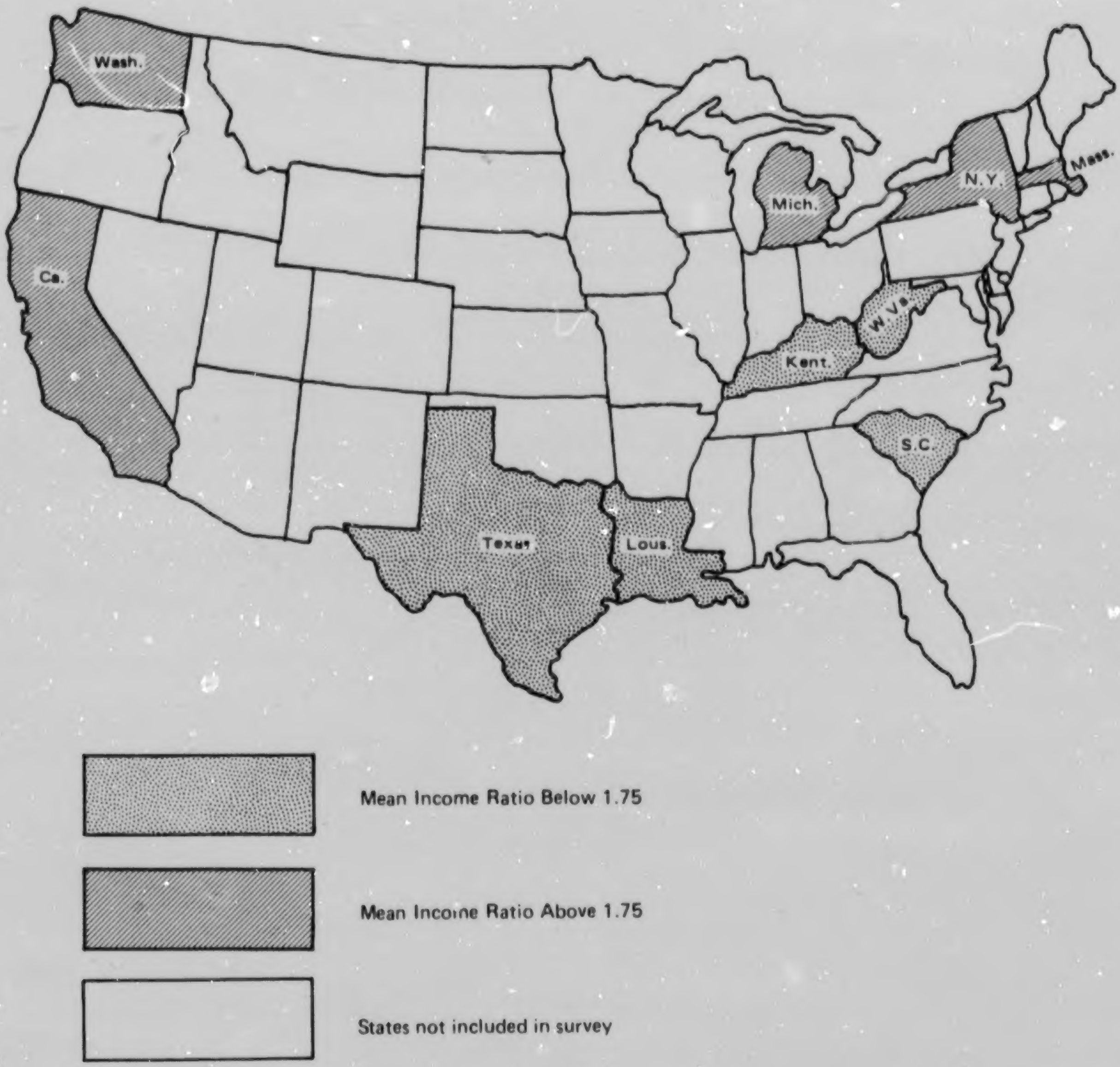
Wash.
Ca.
Mich.
N.Y.
Mass.
W.Va.
Kent.
S.C.
Texas
Lous.
Mean Income Ratio Below 1.75
Mean Income Ratio Above 1.75
States not included in survey

Figure 1

Income Ratios for States Included in Study

Source: (28)

Table 5

Standards for Evaluation of Dietary Intakes

Energy and nutritients by age (yr) Energy (kcal/day)	RDA a	TSNS b	FAO c	MPSNS d
1-2	1,100	980	1,093	900
2-3	1,250	1,204	1,235	1,050
3-4	1,400	1,376	1,376	1,200
4-6	1,600	1,558	1,544	1,425
Energy (kcal/kg/day)				
1-2	92	90	91	75
2-3	89	86	88	75
3-4	88	86	86	75
4-6	84	82	81	75
Protein (gm/day)				
1-2	25	23	13	18
2-3	25	24	14	21
3-4	30	27	16	26
4-6	30	29	18	28
Protein (gm/kg/day)				
1-2	2.0	1.9	1.1	1.5
2-3	1.8	1.7	1.0	1.5
3-4	1.8	1.7	1.0	1.5
4-6	1.6	1.5	1.0	1.5
Calcium (mg/day)				
1-2	700	450	450	400
2-3	800	450	450	400
3-4	800	450	450	400
4-6	800	450	450	400
Iron (mg/day)				
1-2	15	15	5	8
2-3	15	15	5	8
3-4	10	10	5	8
4-6	10	10	5	8
Vitamin A (IU/day)				
1-2	2,000	2,000	1,417	420
2-3	2,000	2,000	1,417	490
3-4	2,500	2,000	1,417	595
4-6	2,500	2,000	1,750	665

Table 5 (Continued)

Standards for Evaluation of Dietary Intakes

Energy and nutritients by age (yr) Energy (kcal/day)	RDA a	TSNS b	FAO c	MPSNS d
Thiamin (mg/day)				
1-2	0.6	0.4	0.4	0.3
2-3	0.6	0.5	0.5	0.4
3-4	0.7	0.6	0.6	0.4
4-6	0.8	0.6	0.6	0.5
Riboflavin (mg/day)				
1-2	0.6	0.6	0.6	0.4
2-3	0.7	0.7	0.7	0.5
3-4	0.8	0.8	0.8	0.6
4-6	0.9	0.9	0.9	0.6
Vitamin C (mg/day)				
1-2	40	40	20	15
2-3	40	40	20	15
3-4	40	40	20	15
4-6	40	40	20	15

[a] Recommended Daily Allowance

[b] Ten-State Nutrition Survey

[c] Food and Agriculture Organization

[d] Mississippi Preschool Nutrition Survey

Source: (20)

General findings were in accord with the Ten-State Nutrition Survey and the Preschool Nutrition Survey. Signs of high risk of deficiency were generally low (11). More often subclinical deficiency (lacking manifestations) due to inadequate intake is the problem. This deficiency now seems universal to all highly industrialized countries of North America and Europe. There were a few observations worthy of mention:

1. Most clinical manifestations of dietary deficiencies increase with age.

2. Many of these dietary deficiencies accompany other diseases.

3. Blacks show more deficiency signs than whites in the same age, sex, and income groups.

4. Protein deficiency is not as great a problem in the United States as it is in the developing countries (15).

Nutritional Status of North American Indian Children, 1972 (18)

In earlier status surveys white, black, and Spanish-American segments of our American people have been investigated. But what about the nutritional status of the North American native child? Is this segment of our society also suffering the effect of chronic long-term undernutrition? Or, has this native child somehow escaped the ills of the rest of the industrialized North America and Europe?

Most North American Indians and Alaskan natives, the first Americans, face severe hardships. Their yearly incomes are less than the national average. Their unemployment, infant mortality, and teenage suicide rates are higher than the national average (18). Most of these children, whose nutritional and developmental problems are extreme under these circumstances, are classified as disadvantaged. The very rare cases of severe malnutrition were associated with child neglect. What emerged from studies concerning the status of these native children is an old, tiresome story of chronic undernutrition, which,unfortunately,is a constant, self-perpetuating companion to poverty (Figure 2). This poverty-malnutrition cycle is reflected in these children who have lower height and weight than their more affluent counterparts. Nutritional surveys indicate that this group generally has a low intake of vitamin A, vitamin C, calcium, and iron in comparison with recommended intakes. Protein intake is described as borderline but adequate. The exception to marginal protein intake is the Alaskan native and the Eskimo whose intake is more than adequate (6, 22, 23). Thus, the nutritional plight of the disadvantaged native American child is similar to that of any poor child in our society.

Study of Nutritional Status of English Children, 1973 (10)

A comparison of American and English children is presented in an English study concerning the nutritional status of children and the influence of any socioeconomic factors on that status (10). The study used as a sample 1,017 children whose rate of response was 76.5 percent. The data gathered were a one-week weighed diet* record, a socioeconomic questionnaire (both supervised by the same trained worker), and a medical examination. The aim of the study was to determine the extent of malnutrition and its relationship to health and socioeconomic factors. When average daily intake was compared with English standards, a child's age, sex, and weight exerted great influence on the results, while social class, number of children in the family, and mother's working status did not. However, when nutrient intake per 1,000 kilocalories (kcal) was considered, the results were not consistent for a child's age and sex. Weight differences were significant only as concerns the intake of sugar per 1,000 kcal. Variations of nutrients per 1,000 kcal between social classes and family sizes closely paralleled the height and weight differences found

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*A weighed diet means the weight of all items consumed is controlled.

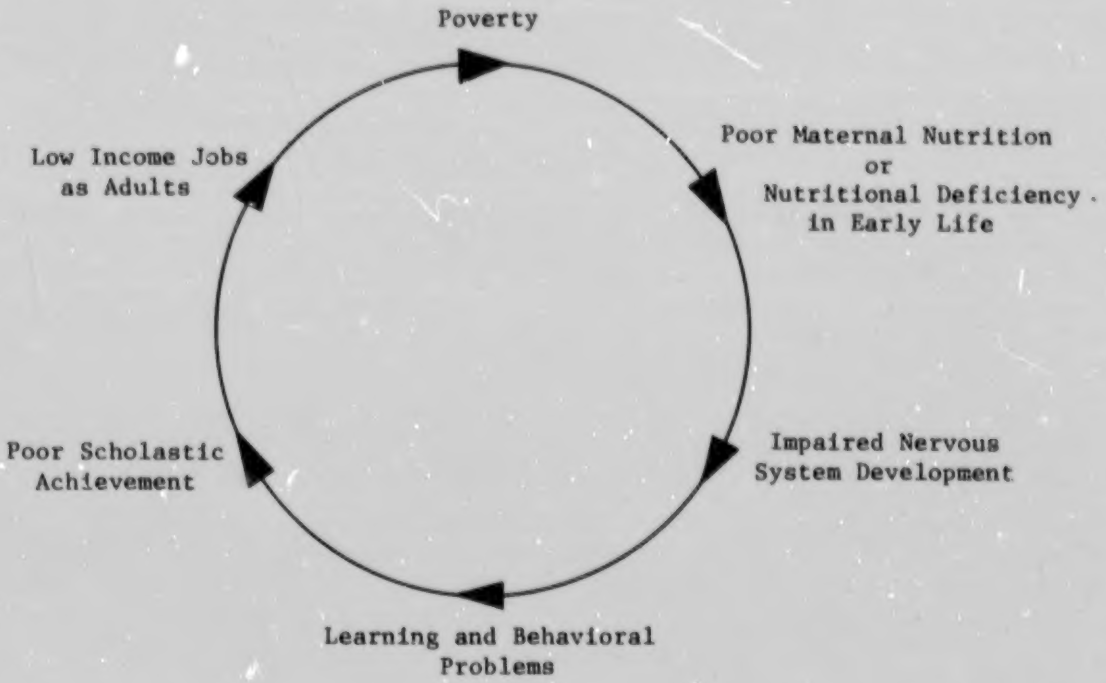

Poverty
Poor Maternal Nutrition or Nutritional Deficiency in Early Life
Impaired Nervous System Development
Learning and Behavioral Problems
Poor Scholastic Achievement
Low Income Jobs as Adults

Figure 2

Self-Perpetuating Saga of Poverty to Poor Nutrition, to Poor Achievement, to Poverty

Source: (2)

in earlier studies (27). Children from larger families and lower social classes had poorer nutrient quality in their diets per 1,000 kcal, in comparison with English standards, than children from better social conditions. This finding reveals that poorer social classes use cheaper sources of nutrients, for example sugar, to meet caloric requirements. Results show that energy levels were low for all age groups; values of vitamins A and C were much higher than recommended; and calcium also was high, particularly for the boys. Note should be made here that English standards of daily requirements vary somewhat from United States suggested requirements. All other values closely approximate suggested amounts. The 1964 daily required allowances in England are based partially on 1947 recommended amounts. Updating of these values to correspond to changed needs might show that energy values were, in fact, adequate.

The research staff, who took a large sample of school children, employed a week-long weighed diet for accuracy of data. The results were observed from the viewpoint of total daily intake and of nutrients per 1,000 kcal. This approach gives a much more complete picture of total nutritional status, and these techniques should be incorporated in status studies of United States children.

Nutritional Status of California Children (2)

No comprehensive study exists that has investigated the nutritional status of all California children. Various groups of these children have been selected for small-status studies. Usually,these samples were selected because they were suspected of being "at risk" nutritionally. "At risk" is the terminology applied to those groups or individuals who most often exhibit a low intake of one or more nutrients (low meaning less than RDA). Infants, preschool children, and adolescents fall into this category, as do the poor and minority groups. The results of these studies cannot be applied to all California children but must be viewed instead as representative of only the sample under investigation.

The largest minority group in California is the Mexican-Americans. The diets of these children from rural areas consistently exhibit low intakes of iron. Growth retardation, poor dental health, and obesity followed in descending order of prevalence (1, 3, 4, 5, 9, 12). The diets of urban children of Mexican-American descent were most lacking in folic acid, followed by vitamin E, vitamin D, and vitamin A (7).

In reference to the California black child, the Marin County study (24) gives a good overall picture. This study revealed that a large percentage of these children were consuming less than two-thirds of the Recommended Daily Allowances for iron, vitamin A, folic acid, and vitamin B12 (24). Other studies concerning black California children were reviewed and documented (2) and essentially were found to be comparable to other national large-scale studies (21, 28). A summary of all California status studies with note made of specific findings is included in Nutrition in California (2). These studies do not have special references to the poor white or the poor oriental child.

Nutrition Canada (25)

"Nutrition Canada," initiated in September 1970 and completed in December 1972, was the name given to the study of nutritional health of Canadians (25). The objectives were as follows:

> a. To determine the prevalence of nutritional disorders among Canadians on the basis of: geographic location (provincial and regional); type of community (metropolitan, urban, or rural); season; age and sex; pregnancy; and income level. Prevalence determinations are based on assessment of: clinical evidence; anthropometric measurements; biochemical determinations on blood and urine samples; and dietary intakes of each nutrient.
>
> b. To identify by quality and quantity the food items consumed by the Canadian public. This provides, in addition to the nutrient intake of each individual, an understanding of food consumption patterns across the nation and the degree of variation in such patterns; permits the re-evaluation of food enrichment and fortification policies and programs; and the estimation of consumption of substances, such as food additives and pesticide residues. (25:6)

Over 19,000 persons of all ages were involved in this study. Incidences of obesity and elevated serum cholesterol levels suggested dietary indiscretions and the lack of exercise among a large proportion of Canadians. Iron deficiency affected large numbers of Canadians, and protein and/or calorie deficiency surfaced among a few pregnant women and a few young children. The next nutrients lacking, in descending order, were calcium, vitamin D, and vitamin C. Most often the vitamin C deficiency appeared in the Indian and Eskimo segments of the population. Thiamin was the only B vitamin deficiency that appeared, and this lack more often occurred in men in the general and Indian populations. Children and pregnant Indian and Eskimo women occasionally exhibited a deficit of vitamin A, which was evidenced in the serum of the children and in the dietary intakes of the pregnant women (25).

The most surprising discovery to emerge from this study was the low serum folate levels among large numbers of Canadians of all ages. The clinical significance of this finding will necessitate further hematological study. Another puzzling discovery is the prevalence, especially in the prairie regions, of enlarged goiters among the population although their iodine intake is adequate. The clinical significance of this fact also will necessitate further research.

Seasons, community income, and type of community exerted no consistent effect on the nutritional status of the general population. Data for the Eskimo and Indian concerning these points were analyzed at a later date.

As a result of this study, the need for a national nutrition policy was established. With the application of a strong nutrition policy, the Canadian government hopes to categorize nutritional problems and treat them before they reach such large proportions that the Canadian quality of life is harmed (25).

Conclusions

All of the status studies described certainly exhibit some questionable research techniques. In many cases the sample was not representative of the total population. In other cases the accuracy of the data is questionable. The word of a mother concerning the food her child consumed for a period of one or two days is not a scientific response. Even if that same food were weighed and measured with precision, a 24- or a 48-hour diet history is really not sufficient evidence to form a concrete conclusion. However, even with these questionable techniques, the results of the surveys were similar. The findings of the four largest status studies are summarized in Table 6.

None of the studies revealed evidence of severe, widespread malnutrition; nor did any suggest the prevalence of terrible, widespread hunger. Instead they indicated that moderate under- and overnutrition do in fact exist in American and California children. These studies pointed to the relationship between economic levels and evidences of nutritional lack. Great gaps in our present knowledge were revealed. For example, racial growth differences should, in the future, influence nutritional assessments. Most importantly, however, all these surveys reinforced the idea that assessment of nutritional status is not a "one-look" type of study but should be an ongoing process in which results of one decade are consistently gathered and combined with the changes in life-style, needs, and habits in the following decade to ensure a more healthful and productive future generation.

Table 6

Summary of Major Status Studies

Study	Subjects	Methodology	Major Findings
Preschool children in the United States	3,441 children from 1-to-5 years old	Analysis 1. Dietary interview (on all 3,441 children)	1. Dental caries most prevalent among the low-income group and the black group
		2. Clinical and biochemical (on 2/3 of the children)	2. Anthropometric studies showed black children are taller than whites
		3. Socioeconomic	3. Insufficient food among the low-income group was the major nutrition problem
		4. Anthropometric	4. Protein-adequate
		5. Dental exam	5. Vitamin C intake was low in the low-income group
			6. Blood hemoglobin lowest in low-income black group
			7. Vitamin A levels (blood) higher in blacks than whites
Ten-State Nutrition Survey	40,000 persons from 10 states (divided) into low- and high-income states and again divided by age, sex, race	1. Physical exam	1. Low-income blacks and Spanish-Americans more prone to malnutrition than whites
		2. Anthropometric measurements	2. Growth retardation more prevalent in low-income areas. Social, culture, and geography influenced nutrition
		3. Dental exams	3. Bad nutritional status most prevalent in the 10- to 16-year age group

Table 6 (Continued)

Summary of Major Status Studies

Study	Subjects	Methodology	Major Findings
		4. Hematocrit and hemoglobin determination	4. Obesity was prevalent among adult females, especially blacks, and among children and adolescents
		5. Selected groups had more biochemical tests and individual diet evaluation	5. Widespread low hemoglobin
			6. Poor dental health prevalent
			7. Low serum albumin in pregnant and lactating women even though diet appeared adequate
			8. Young people had high incidence of low vitamin A levels, most prevalent being the Mexican area Spanish-Americans
			9. Vitamin C deficiency most prevalent in males and older persons
			10. Poor riboflavin status among blacks and young people of all ethnic groups

Table 6 (Continued)

Summary of Major Status Studies

Study	Subjects	Methodology	Major Findings
Health and Nutrition Examination Survey	Preliminary group--10,126 (from 1-74 years)		Over half of the group showed these results:
		1. 24-hour recall of diet	1. Low transferrin saturation in children 1 to 5 years. Low hemoglobin and hematocrit in older groups, especially low-income blacks
		2. Clinical exam	2. Low serum vitamin A especially in low-income blacks
		3. Biochemical	3. Low serum protein values in all age groups and in white groups at all economic levels
		4. Anthropometric measurements	4. Low iron intake was the most prevalent low nutrient intake
		5. Concentration of chronic disease	5. Vitamin A and vitamin C intakes below the standard in 73 percent of lower income white women, age 18 to 44 and in higher income black girls, age 12 to 17
		6. Socioeconomic evaluation	6. Significant anthropometric measurements between low- and high-income groups
			7. High prevalence of obesity, especially among women, highest prevalence for black women, age 45-74

Table 6 (Continued)

Summary of Major Status Studies

Study	Subjects	Methodology	Major Findings
Nutrition Canada	15,000 persons (1,000 women in third trimester of pregnancy), Indians and Eskimos included	1. Biochemical evaluation	1. Overweight was found in 40 percent of adults age 20 to 39 and 60 percent of adults over 60
		2. Clinical evaluation	2. Calorie intake was lower for women than men, so overall intakes of vitamins (except C) and minerals were lower for women
		3. Anthropometric measurements	3. Serum cholesterol values for 10 percent of the men and 14 percent of the women were at risk
		4. Dietary intakes	4. Dietary intakes of iron were low for all. Transferrin saturation was low for all
		5. Determination of type of community	5. Calcium and vitamin D intakes were low in the diets of many infants, children, and adolescents
			6. Season, income, or kind of community had no consistent effect on nutritional status

Bibliography

1. Acosta, P. B., and others. "Nutritional Status of Mexican-American Preschool Children in a Border Town," The American Journal of Clinical Nutrition, 27(12) (December 1974), 1359-1368.

2. Brothers, S. R. Nutrition in California. ADR No. 27. Sacramento, California: Assembly Office of Research, November 1976.

3. Bruhn, C. M., and others. "Food Habits of Migrant Farm Workers in California," Journal of the American Dietetic Association, 58(5) (May 1971), 417-420.

4. Burkitt, D. P., and others. "Dietary Fiber and Disease," Journal of the American Medical Association, 229(8) (August 1974), 1068-1074.

5. Burroughs, A. L., and others. "Iron Deficiency in Rural Infants and Children," Journal of the American Dietetic Association, 57(2) (August 1970), 122-128.

6. Carlile, W. K., and others. "Contemporary Nutritional Status of North American Indian Children," Nutrition, Growth and Development of North American Indian Children. Eds. W. M. Moore, M. M. Silverberg, and M. S. Read. DHEW Publication No. (NIH) 72-26, Washington: Government Printing Office, 1972.

7. Castillo, R. O. "The Nutritional Status of Urban Mexican-American Children." Unpublished paper, University of California, Berkeley, May 1975.

8. Christakis, G. ed. Nutritional Assessment in Health Programs. Washington: American Public Health Association, Inc., November 1973.

9. Compton, A. S. "Health Study of Adolescents Enrolled in the Neighborhood Youth Corps," U.S. Department of Health, Education, and Welfare Public Health Reports, 84(7) (Fall 1969), 39-57.

10. Cook, J., and others. "A Survey of the Nutritional Status of Schoolchildren--Relation Between Nutrient Intake and Socio-Economic Factors," British Journal of Preventive and Social Medicine, 27(2) (May 1973), 91-99.

11. Garn, S. M., and D. C. Clark. "Nutrition, Growth, Development, and Maturation: Findings from the Ten-State Nutrition Survey of 1968-1970," Pediatrics, 56(2) (August 1975), 306-319.

12. Gladney, V. M. "Food Practices of the Mexican-American in Los Angeles County." County of Los Angeles Department of Health Services, July 1972.

13. Jelliffe, D. B. The Assessment of the Nutritional Status of the Community. No. 53. Geneva: World Health Organization Monograph Series, 1966.

Bibliography (Continued)

14. Lowe, C. U., and others. "American Academy of Pediatrics Committee Statement--The Ten-State Nutrition Survey: A Pediatric Perspective," *Pediatrics*, 51(6) (June 1973), 1095-1099.

15. Lowenstein, F. W. "Preliminary Clinical and Anthropometric Findings from the First Health and Nutrition Examination Survey, USA, 1971-1972," *The American Journal of Clinical Nutrition*, 29 (August 1976), 918-927.

16. Mayer, J. ed. *U. S. Nutrition Policies in the Seventies*. San Francisco: W. H. Freeman and Company, 1973.

17. McLaren, D. S. ed. *Nutrition in the Community*. London, New York, Sydney, and Toronto: John Wiley and Sons, 1976.

18. Moore, W. M., M. M. Silverberg, and M. S. Read, eds. *Nutrition, Growth and Development of North American Indian Children*. DHEW Publication No. (NIH) 72-26. Washington: Government Printing Office, 1972.

19. Obert, J. C. *Community Nutrition*. New York, Santa Barbara, Chichester, Brisbane, and Toronto: John Wiley and Sons, 1978.

20. Owen, G. M., and K. M. Kram. "Nutritional Status of Preschool Children in Mississippi," *Journal of the American Dietetic Association*, 54(6) (June 1969), 490-494.

21. Owen, G. M., and others. "A Study of Nutritional Status of Preschool Children in the United States, 1968-1970," *Pediatrics*, 53(4) (April 1974), 597-646.

22. Owen, G. M., and others. "Nutrition Survey of White Mountain Apache Preschool Children," *Nutrition, Growth and Development of North American Indian Children*. Eds. W. M. Moore, M. M. Silverberg, and M. S. Read. DHEW Publication No. (NIH) 72-26. Washington: Government Printing Office, 1972.

23. Reisinger, K., K. D. Rogers, and O. Johnson. "Nutritional Survey of Lower Greasewood, Arizona Navajos," *Nutrition, Growth and Development of North American Indian Children*. Eds. W. M. Moore, M. M. Silverberg, and M. S. Read. DHEW Publication No. (NIH) 72-26. Washington: Government Printing Office, 1972.

24. Ruffin, M., and others. "Nutritional Status of Preschool Children of Marin County Welfare Recipients," *The American Journal of Clinical Nutrition*, 25(1) (January 1972), 74-84.

25. Sabry, Z. I., and others. "Nutrition Canada," *Nutrition Today*, 9(1) (January-February 1974), 5-13.

26. Shapiro, L. R. "The Ten-State Nutrition Survey in California: A Critical Analysis." Ph.D. Thesis, University of California, Berkeley, 1974.

Bibliography (Continued)

27. Topp, S., and others. "Measurement of Nutritional Intake Among Schoolchildren," British Journal of Preventive and Social Medicine, 26(2) (May 1972), 106-111.

28. U. S. Center for Disease Control, Atlanta, Ten-State Nutrition Survey, 1968-1970, DHEW Publication No. (HSM) 72-8134, 1972.

CHAPTER 3

Evidence of Nutritional Deficiency

Severe malnutrition, which mainly occurs in the world's underdeveloped countries, causes marasmus and kwashiorkor, diseases which are widespread among malnourished infants.

Severe Malnutrition and Degree of Prevalence

Malnutrition is generally a condition of improper nutriture intake. Figure 3 (20) shows the various factors contributing to malnutrition. Although malnutrition comprises both over- and undernutrition, this section discusses the results of undernutrition. Figure 4 shows the multitude of causes that could result in malnutrition (20). Cases of severe nutritional deprivation are seldom seen in the developed countries of the world. However, this severe type of malnutrition is the fate of 1 to 2 percent of the world's children from the developing countries (22). Malnutrition is manifested in two basic deficiency diseases: marasmus and kwashiorkor.

Marasmus

Marasmus, which occurs most often in children under one year of age, is accompanied by severe wasting of tissue and stunted growth. This disease is the result of insufficient food, especially calories and surfaces most often upon early cessation of breast feeding of the infant (12, 17). This severe deficiency disease seems to be on the increase in developing countries (18).

Kwashiorkor

Kwashiorkor generally occurs after the infant has been weaned from mother's milk or from formula (18, 22). The diet of the children exhibiting this severe deficiency disease is greatly deficient in protein. This disease, which is becoming less prevalent, causes stunted growth, edema, skin sores, and loss of natural hair color. Both of these deficiency diseases, marasmus and kwashiorkor, cause altered growth patterns, behavioral abnormalities, and in selected severe cases, produce permanent effects (13, 30).

Chronic or Long-Term Undernutrition and Degree of Prevalence

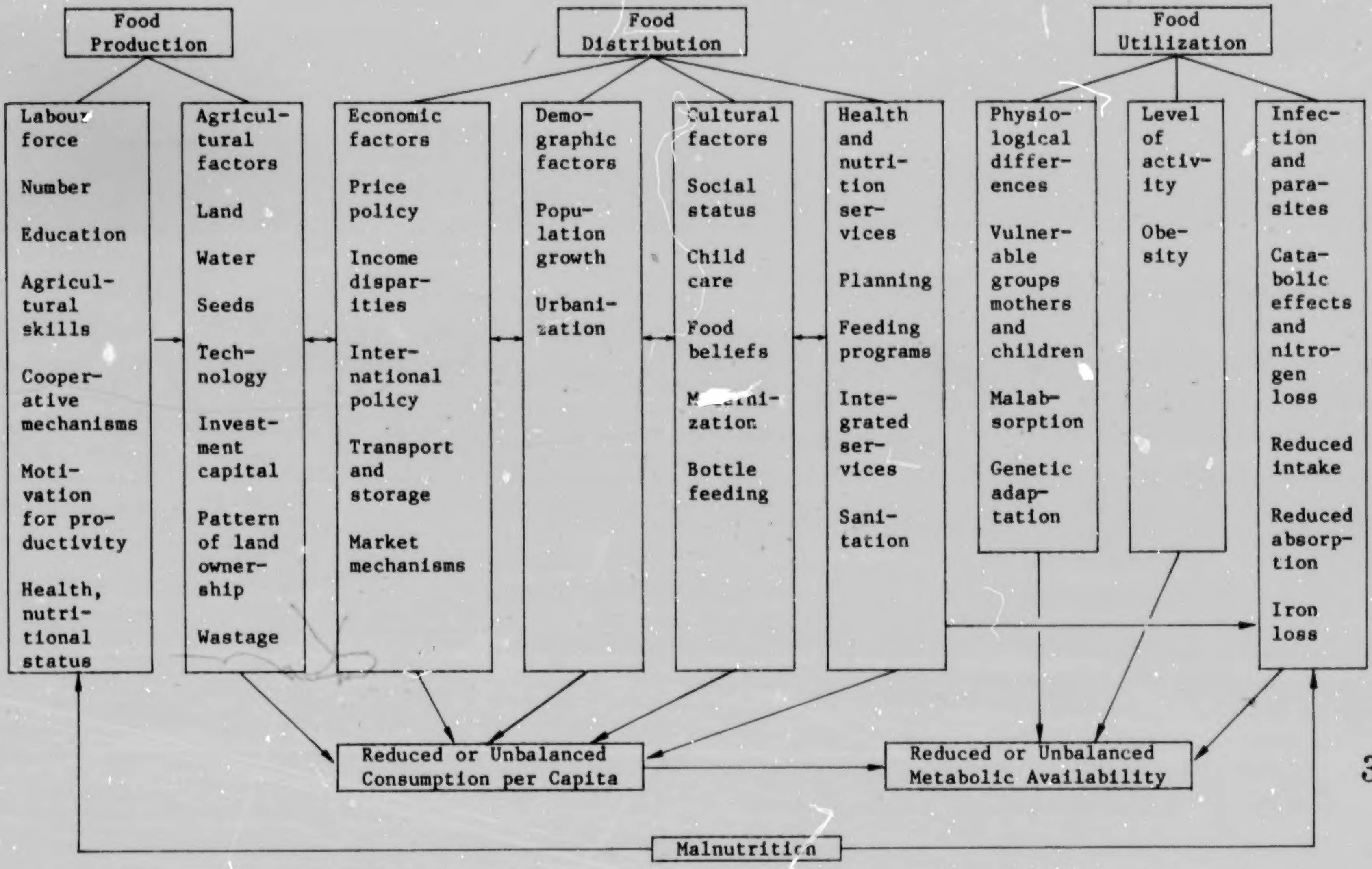
Various kinds of chronic undernutrition prevalent in the United States--calorie deficiency, iron deficiency, insufficient vitamin intake, and hunger--were the subjects of nutritional status studies.

Calorie Deficiency

Status studies in the United States, reveal that the aforementioned severe deficiency diseases, marasmus and kwashiorkor, are very rare indeed (10, 22).

Figure 3

Diagrammatic Model Showing Multi-Factorial Causation of Malnutrition


Food Production
Food Distribution
Food Utilization
Labour force
Number
Education
Agricultural skills
Cooperative mechanisms
Motivation for productivity
Health, nutritional status
Agricultural factors
Land
Water
Seeds
Technology
Investment capital
Pattern of land ownership
Wastage
Economic factors
Price policy
Income disparities
International policy
Transport and storage
Market mechanisms
Demographic factors
Population growth
Urbanization
Cultural factors
Social status
Child care
Food beliefs
Modernization
Bottle feeding
Health and nutrition services
Planning
Feeding programs
Integrated services
Sanitation
Physiological differences
Vulnerable groups mothers and children
Malabsorption
Genetic adaptation
Level of activity
Obesity
Infection and parasites
Catabolic effects and nitrogen loss
Reduced intake
Reduced absorption
Iron loss
Reduced or Unbalanced Consumption per Capita
Reduced or Unbalanced Metabolic Availability
Malnutrition

Source: (20)

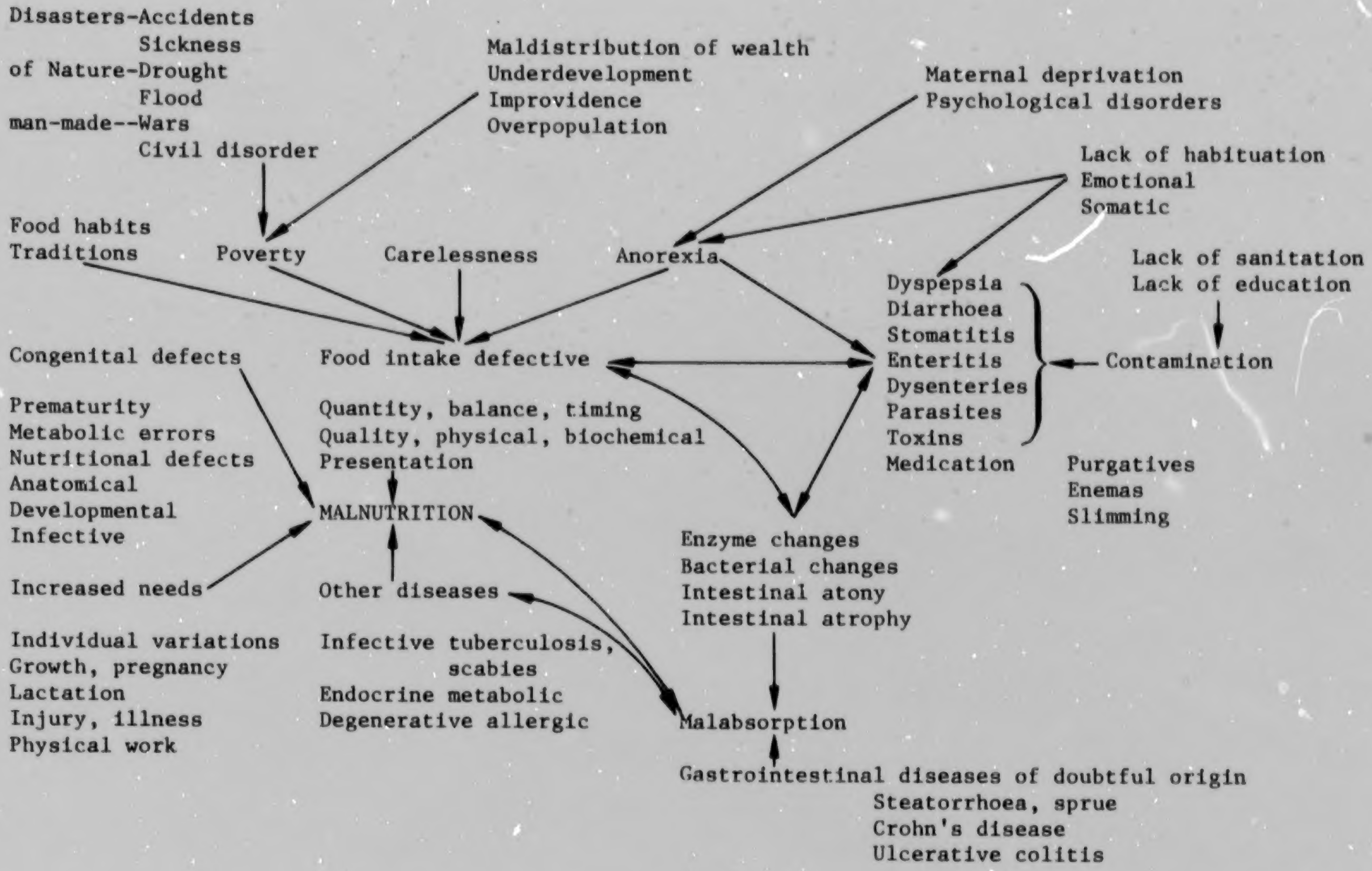

Disasters-Accidents
Sickness
of Nature-Drought
Flood
man-made--Wars
Civil disorder
Maldistribution of wealth
Underdevelopment
Improvidence
Overpopulation
Maternal deprivation
Psychological disorders
Lack of habituation
Emotional
Somatic
Food habits
Traditions
Poverty
Carelessness
Anorexia
Lack of sanitation
Lack of education
Dyspepsia
Diarrhoea
Stomatitis
Enteritis
Dysenteries
Parasites
Toxins
Medication
Contamination
Purgatives
Enemas
Slimming
Congenital defects
Food intake defective
Prematurity
Metabolic errors
Nutritional defects
Anatomical
Developmental
Infective
Quantity, balance, timing
Quality, physical, biochemical
Presentation
MALNUTRITION
Increased needs
Other diseases
Enzyme changes
Bacterial changes
Intestinal atony
Intestinal atrophy
Individual variations
Growth, pregnancy
Lactation
Injury, illness
Physical work
Infective tuberculosis,
scabies
Endocrine metabolic
Degenerative allergic
Malabsorption
Gastrointestinal diseases of doubtful origin
Steatorrhoea, sprue
Crohn's disease
Ulcerative colitis

Figure 4

Causes of Undernutrition

Source: (20)

Malnutrition exists in this country as an insidious, long-term type of undernutrition. Status studies also show that twenty percent of American children under six years of age consume fewer calories than are recommended (22). Chronic caloric undernutrition manifests itself by poor scores in the A, B, C, D, and Es of assessment studies mentioned previously (anthropometric, biochemical, clinical, dietary, and ecological, pp. 4, 5) (26, 27).

Iron Deficiency

Many studies have shown iron to be the most deficient nutrient in the diet of American children (1, 2, 3, 4, 5, 11, 22, 27, 28). The Ten-State Nutrition Survey conducted from 1968 to 1970 revealed that approximately 15 to 20 percent of the population of the United States is iron deficient (27). A lack of iron is the most prevalent nutrient deficiency which exists regardless of one's socioeconomic class, age, or sex. However, this deficiency occurs more frequently among children from one to three years of age and in lower socioeconomic groups (21, 27). The lower hematocrit levels that were found among Spanish-American and black peoples than among the whites indicate a possible socioeconomic correlation (8, 27). Anemia, the medical result of inadequate iron, is a common occurrence in young children. When a child is five years old, the prevalence of lack of iron seems to disappear only to appear once more in the next period of rapid growth, adolescence (4, 9, 11, 22).

Traditionally, the iron status of a group is determined by measuring the prevalence of anemia and then establishing the cause. More specific tests are required because false values have been noted for both anemic and normal subjects. In 1976, Cook and others (6) presented more sensitive methods of determining iron status. By determining when transferrin saturation falls below 15 percent and when red cell protoporphyrin increases, one can identify twice as many iron-deficient subjects than by hemoglobin determination alone. However, these values remain normal until all iron stores are totally depleted.

If routine measurements of iron stores were possible, the extent and degree of iron deficiency could be determined. Walters and others in 1973 (29) and Cook and others in 1974 and again in 1976 (6) showed that the serum ferritin value more closely reflects the differences in iron stores and should be measured. The employment of a series of laboratory measurements produces greater accuracy in detecting iron deficiency (2, 6, 21).

Other Evidence of Deficiency

Evidences of lower than recommended or deficient intakes of vitamin A (1, 10, 11, 26, 27, 28), vitamin C (1, 3, 10, 11, 25, 26, 27, 28), riboflavin (26, 27, 28), folacin (3, 25, 26, 27, 28), and calcium and vitamin D (11, 26, 27, 28) have been shown by the large status studies and also by the smaller status studies. No gross deficiencies have been noted in the studies reviewed.

Hunger

"What is the chronic hunger of malnutrition and how widespread is it?" Mayer concedes that the first part of this question is answerable, but to determine the extent of hunger is a matter of educated guessing (19).

Malnutrition is a state of over- and undernutrition resulting in faulty function or development due to excess or lack of one or more nutrients or calories over an extended period of time (23, 24). "Hunger is a psychologic and physiologic state resulting from insufficient food intake to meet immediate energy needs" (24). Hunger is a problem that can be cured with immediate treatment. In other words, food eliminates hunger, while malnutrition, a problem acquired over a long period of time of abuse, requires extended periods of treatment. Although these two states, hunger and malnutrition, are closely related, they are not the same (24).

Hunger has been observed in certain areas of the United States. In general, people inhabiting the slums, large areas in the southeastern United States, the Appalachian region, and Indian reservations have all shown signs of hunger, as have such groups as migrant workers, disabled persons, and the elderly (7). There is no reliable estimate of the number of Americans who are hungry (7, 16).

The exact extent of hunger is impossible to determine (19, 22, 24), but the physical manifestations are easy to observe: Nervousness and irritability and decreased ability to learn are the results of hunger (22, 24). These same symptoms appear in both children and adults. Even in cases of extreme deprivation, relief from these symptoms is brought about by adequate food intake (15).

The problem of hunger compounds the difficulty a child faces in school. Nervousness, irritability, and decreased interest further isolate the child from the persons surrounding him and add more obstacles to the learning process (22, 24).

Conclusions

Research studies indicate that severe malnutrition is infrequent in the United States. However, questions yet to be answered are: What is the effect of moderate or chronic undernutrition on the human body and on the learning process? Do mildly deficient intakes of one or more nutrients hinder a person from reaching his or her physical and mental capacity? Are recommended daily allowances in excess of bodily need? Or, on the other hand, has the human body simply adapted? (Adaptation implies a change in the body caused by a change in the environment.) All these unanswered questions point once more to the need for ongoing status studies and testing to find the correct conclusions.

While there has been much focus on the effects of malnutrition on the school child, little attention has been paid to the problem of hunger, which may be an even more harmful deterrent to the learning process in the child than malnutrition. Quite obviously, more research must be directed toward eradicating those aspects of society that nurture the existence of hunger (10). Hunger affects all levels of society and is more often associated with poverty. Hunger, however, is not confined exclusively to this economic state.

Bibliography

1. Acosta, P. B., and others. "Nutritional Status of Mexican-American Preschool Children in a Border Town," The American Journal of Clinical Nutrition, 27(12) (December 1974), 1359-1368.

2. Burroughs, A. L., and others. "Iron Deficiency in Rural Infants and Children," Journal of the American Dietetic Association, 57(2) (August 1970), 122-128.

3. Castillo, R. O. "The Nutritional Status of Urban Mexican-American Children." Unpublished paper, University of California, Berkeley, May 1975.

4. Compton, A. S. "Health Study of Adolescents Enrolled in the Neighborhood Youth Corps," U. S. Department of Health, Education, and Welfare Health Reports, 84(7) (July 1969), 585-596.

5. Contra Costa County Health Department, Division of Community Health Services, Nutrition Section, "Iron Deficient Anemia in Infants in Contra Costa County." Unpublished paper.

6. Cook, J. D., and others. "Evaluation of the Iron Status of a Population," Blood, 48 (September 1976), 449-455.

7. Council on Foods and Nutrition. "Malnutrition and Hunger in the United States," Journal of the American Medical Association, 213(2) (July 1970), 272-275.

8. Ershoff, B. H. "Comparative Microhematocrit Values of Spanish-American and Whites Attending Los Angeles Youth Clinics," Public Health Reports, 90 (January-February 1975), 58-61.

9. Finch, C. A., and J. D. Cook. "Iron in Human Nutrition." Proceedings of the Ninth International Congress of Nutrition, Mexico, 1972. Eds., A. Chavez, and others. Muchen, Paris, London, New York, and Sydney: S. Karger-Basel, 1975.

10. Garn, S. M., and D. C. Clark. "Nutrition, Growth, Development, and Maturation: Findings from the Ten-State Nutrition Survey of 1968-1970," Pediatrics, 56(2) (August 1975), 306-319.

11. Hampton, M. C., and others. "Calorie and Nutrient Intakes of Teenagers," Journal of the American Dietetic Association, 50(5) (May 1967), 385-396.

12. Jelliffe, D. B., and E. F. P. Jelliffe. "The Uniqueness of Human Milk," The American Journal of Clinical Nutrition, 24(8) (August 1971), 967-1024.

13. Jelliffe, D. B., and H. F. Welbourn. "Clinical Signs of Mild-Moderate Protein-Calorie Malnutrition of Early Childhood." Symposia of the Swedish Nutrition Foundation. Ed. Gunnar Blix. Sweden: Almqvist and Wiksells, 1963.

Bibliography (Continued)

14. Kallen, D. J. ed. Nutrition, Development and Social Behavior. U. S. Public Health Service, DHEW Publication No. (NIH) 73-242, 1973.

15. Keys, A., and others. The Biology of Human Starvation. Vol. 2. Minneapolis: University of Minneapolis Press, 1950.

16. Kotz, N. Let Them Eat Promises, The Politics of Hunger in America. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969.

17. Latham, M. C. "Nutritional Problems of Tanganyika." Proceedings of the 6th International Congress of Nutrition. Edinburgh: Livingstone, 1964.

18. ____________. "Protein-Calorie Malnutrition in Children and Its Relationship to Psychological Development and Behavior," Psychological Reviews, 54(2) (July 1974), 541-565.

19. Mayer, J. "The Dimension of Human Hunger," Scientific American, 235(3) (September 1976), 40-49.

20. McLaren, D. S. ed. Nutrition in the Community. London, New York, Sydney, and Toronto: John Wiley and Sons, 1976.

21. Pollitt, E., and R. L. Leibel. "Iron Deficiency and Behavior," Journal of Pediatrics, 88 (March 1976), 372-381.

22. Read, M. S. Malnutrition, Learning, and Behavior. DHEW Publication No. 76-1036. Bethesda, Md: National Institute of Health, April 1976.

23. ___________. "Malnutrition, Hunger and Behavior I. Malnutrition and Learning," Journal of the American Dietetic Association, 63 (October 1973), 379-385.

24. ___________. "Malnutrition, Hunger and Behavior II. Hunger, School Feeding Programs, and Behavior," Journal of the American Dietetic Association, 63 (October 1973), 386-391.

25. Ruffin, M., and others. "Nutritional Status of Preschool Children of Marin County Welfare Recipients," The American Journal of Clinical Nutrition, 25(1) (January 1972), 74-84.

26. Shapiro, L. R. "The Ten-State Nutrition Survey in California: A Critical Analysis." Ph.D. Thesis, University of California, Berkeley, 1974.

27. U. S. Center for Disease Control, Atlanta, Ten-State Nutrition Survey, 1968-1970, DHEW Publication No. (HSM) 72-8134, 1972.

28. U. S. Department of Health, Education, and Welfare, Preliminary Findings of the First Health and Nutrition Examination Survey, United States, 1971-1972. Rockville, Md: National Center for Health Statistics, January 1974.

Bibliography (Continued)

29. Walters, G. O., and others. "Serum Ferritin Concentration and Iron Stores in Normal Subjects," Journal of Clinical Pathology, 26 (1973), 770.

30. Winick, M. Malnutrition and Brain Development. New York: Oxford University Press, Inc., 1976.

CHAPTER 4

Evidence of Improved Nutritional Status

Results from several studies revealed that supplementary food programs improved children's nutritional status.

Study Concerning the Contribution of Milk Program in England

The contribution of the school milk program to the total nutritional status of the 396 British children was investigated in Kent County, England. The children, aged eight to eleven, were offered one-third of a pint of milk each school day. Informative data collected were: a one-week weighed diet record (including the amount of milk drunk), a socioeconomic questionnaire, and a physical examination to determine nutritional status.

There was no increase in height, weight, arm circumference, or skinfold thickness (during the school term) and no increase in obesity associated with school milk consumption. These traits are most probably indications of past dietary practices. As a result of the additional milk intake, the quality of the children's diet increased, and the amount of nutrients the subjects consumed complied more closely with dietary recommendations for English school children. For the boys an increase in calcium and riboflavin was noted, and for the girls animal protein and calcium showed an increase on the days that school milk was consumed (7).

Table 7 depicts changes in dietary quality in relation to milk consumption. Results of the study indicate that the quality of the diet improved when school milk was consumed.

However, results of this school milk study cannot be applied directly to United States children. Here, many children of differing races, particularly black and oriental children, have exhibited an intolerance to milk sugar. Therefore, race must be considered, and the habit of placing so much emphasis on the milk program as a means of improving the nutritional status of all children should be re-evaluated (15).

Study Concerning the Contribution of School Lunch Program in England

The same year, 1975, another English study of the effect of school meals on 778 primary and secondary school children from Kent County, England, showed that more children from lower social groups availed themselves of the school meal than did children from more affluent families. Many of the children were receiving free lunch. The meal added greatly to the overall nutrition of the children and raised the nutrient intakes closer to recommended daily intakes for English children. However, no increase in height, weight, and skinfold thickness was noted during the school year; nor was any obesity directly attributable to the program. As stated previously, these characteristics were probably a result of early nutritional habits. The real value of this study and the one previously described is that the actual amount of lunch consumed was used in calculations rather than the amount of food offered to the children.

Table 7

Comparison of Nutrient Intake and Frequency of School Milk Intake During Diet Record Week

	Boys			Girls			Statiscal Difference[a]	
Number of Days of Diet Record Milk was Drunk	0	1-4	5	0	1-4	5	Boys	Girls
Nutrient								
Energy, kcal	2135	2267	2325	1846	1902	2128	*[b]	***
Animal protein (g)	36.2	43.7	42.8	32.3	36.4	40.6	**	***
Total protein (g)	57.5	66.5	66.5	51.5	54.7	61.1	**	***
Fat (g)	87.1	95.3	95.8	79.0	81.0	90.0	*	**
Carbohydrate (g)	297	303	317	243	253	285		***
Calcium (g)	812	1042	1083	746	873	988	***	
Iron (mg)	10.61	11.24	11.34	9.59	9.04	10.40		
Retinol (mg)	0.85	.98	1.01	1.02	0.94	0.95		
Thiamin (mg)	0.93	1.11	1.11	0.79	0.90	0.98	**	***
Riboflavin (mg)	1.34	1.63	1.72	1.24	1.47	1.55	***	***
Nicotinic acid (mg)	11.2	12.4	12.0	9.35	10.0	10.3		
Ascorbic acid (mg)	47.0	60.9	45.9	39.1	41.3	49.2		*
Cholecalciferol (mg)	1.75	2.98	2.74	1.92	2.33	3.07		
Pyridoxine (mg)	1.09	1.22	1.19	0.94	0.04	1.14		***
Number of children	23	42	94	35	35	83		

[a] Comparison of 0 and 5 day milk intake

[b] *$P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Source: (6)

English standards require 29 grams of protein, 880 kcal, and 32 grams of fat for the lunch meal served to a twelve-year-old child (lower amounts for younger and higher amounts for older children). Data in Table 8 show the different intake levels of children who ate the school lunch as compared with those children who did not partake of the lunch program. Levels of nutrients more closely matched English standards when the children participated in the lunch program. The most dramatic increases in nutrient levels occurred among the older boys.

The school lunch meals served were lower in calories and protein than English standards demanded. Fat and sugar content were higher than desired. However, no increase in childhood obesity or in dental caries was determined (3, 18). The meal contributed more to total nutritional status for those children in greatest need since it supplied a greater proportion of total ingested nutrients per day (6).

Contribution of the Breakfast Program in the United States

The breakfast program was developed through Title I of the Elementary and Secondary Education Act and the Child Nutrition Act of 1966 (16). Because no hungry child can perform to his or her greatest capacity, the aim of this program was to feed those children who arrived at school hungry. The basic breakfast was to include:

1. One-half cup serving fruit or full-strength fruit or vegetable juice or a combination of the above

2. One serving of whole-grain or enriched bread or a three-quarter cup (one ounce) serving of whole-grain, enriched, or fortified cereal or an equivalent quantity of a combination of the above

3. One-half pint fresh fluid milk served as a beverage or on cereal

4. A source of protein to be served as often as practicable

In addition to the regular breakfast, a special breakfast was to be served in those schools designated as needy. To be so designated, a school needed to have 75 percent or more of the breakfast program participants receiving the free or reduced-price meals. The only mandatory difference between the basic breakfast and the special breakfast was that one ounce of meat or meat substitute was to be included in the latter each day. The daily addition of a good source of vitamin C was also recommended (4).

To determine whether the program had any impact on the child's achievement, school attendance, health, or behavior, the Cleveland public schools conducted a study which observed these characteristics for a period from 1968 to 1972 (10). The main objectives of the study were to determine whether as a result of the program, there was any improvement in school attendance, attitudes toward school, and achievement. The results showed that statistical improvements occurred in attendance (10). Investigations by a private firm found improved attitudes, such as alertness, energy attitudes, manners, and

Table 8

Nutrient Intake at Lunchtime - Comparison Between Children Taking School Meals and Those Taking None[a] During One School Week

Nutrient	Boys (8-11)		Girls (8-11)		Boys (13-15)		Girls (13-15)	
	School Meals		School Meals		School Meals		School Meals	
	None	Five	None	Five	None	Five	None	Five
Energy	643.2*[c]	739.2	610.2	675.3	856.5***	1088.6	708.1	710.6
Animal protein (g)	14.7***	19.3	13.8*	16.4	16.2***	24.7	15.1	16.4
Total protein (g)	21.3**	25.6	19.9	22.4	26.0***	33.9	23.1	22.8
Fat (g)	28.0*	32.2	26.5	29.8	38.5***	48.7	31.7	32.3
Carbohydrate (g)	80.5*	92.3	77.4	84.4	107.8***	136.7	87.6	87.4
Calcium (mg)	218.3***	370.5	221.1***	313.6	273.5***	508.4	255.3	302.2
Iron (mg)	4.3	4.81	3.85	4.36	5.04***	6.51	4.51	4.52
Vitamin A (IU)	1413.2	1511.2	1464.0	1449.1	1480.5***	2161.0	1717.5	1382.2
Thiamin (mg)	0.32	0.34	0.29	0.32	0.37***	0.48	0.31	0.31
Riboflavin (mg)	0.47*	0.60	0.45	0.52	0.49***	0.84	0.48	0.53
Nicotinic acid (mg)	4.4	4.29	3.71	3.87	5.01**	5.95	4.31	4.14
Ascorbic acid (mg)	22.8	23.2	19.1	21.1	23.8**	30.4	20.7	20.0
Vitamin D (IU)	23.7*	41.5	29.9*	33.8	24.1***	69.5	34.0	30.7
Pyridoxine (mg)	0.50	0.55	0.44	0.49	0.59***	0.76	0.47	0.50
Added sugar (g)[b]	22.70	23.3	22.1	20.9	28.4*	34.7	23.0	21.2
Number of children	43	88	48	80	43	75	65	68

[a] These children ate home-prepared meals.

[b] Added sugar, any sugar not occurring naturally

[c] *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Source: (7)

motivation. The final objective, improvement in achievement, could not be measured by this study, as other remedial projects which would more directly influence achievement were in progress. Although improvement in nutritional status was not one of the direct objectives of the program, the research staff found that the improvement in health, as indicated by the increase in school attendance and more positive attitudes of children who participated in the program, could be a result of better nutritional status.

Iowa Breakfast Study

Since the foundation of the Cereal Institute, Inc. in 1943, effort was made to determine the effect of breakfast on the status and capabilities of individuals. A ten-year study, the Iowa Breakfast Study, published its results in 1962 (1). Although the study investigated different age groups, the concern of this paper is one particular group; namely, school boys, aged twelve to fourteen, who attended St. Mary's School, Iowa City, Iowa. The boys, who were carefully monitored throughout the testing, were divided into groups and fed various types of breakfast. Analyses of nitrogen, calcium, phosphorous, and iron balances showed that the quantity of these elements in one's breakfast did not significantly alter their utilization. Only in two isolated cases was negative nitrogen balance noted in conjunction with the subjects having no breakfast (1). Also, urinary excretion of thiamin and niacin was not significantly affected by the type of breakfast.

Improvement in total nutritional status was not a stated objective in this particular Iowa study; so no application of result to status was made. This omission does not mean that the breakfast program had no value.

Evaluation of the National School Breakfast Program (22)

In July 1971, the Food Research and Action Center (funded by the Emergency Food and Medical Services Division of the United States Office of Economic Opportunity in 1970) undertook the job of reviewing the National School Breakfast Program. The aims included, among other things, the determination of any lessening of hunger and an evaluation of the nutritional and educational consequences of the program. The results of the study group will be discussed in relationship to behavior and achievement in Chapter 12. Without an accurate record of all daily food intakes, to conclude that the program improved the total nutritional status of the children is not possible (22). However, the improvement, which is well-documented by this study, in enthusiasm, alertness, attendance, punctuality, and general physical condition certainly suggests better nutritional status (22).

Contribution of the Head Start Program to Total Nutritional Status

Improvements having been noted in the breakfast programs, the next logical step was an attempt to improve the nutritional status of the child before he or she attained school age. This attempt was the major rationale for Project Head Start. Impetus for this program came from Title II-A of the Economic Opportunity Act (11). The program, aimed at children from culturally and educationally deprived homes, had as its aim improved nutritional status which would develop better physical and mental capabilities in these children. The program endeavors "to assure the security and well-being of all children--at the same time the nation's most precious and most perishable resources" (14:3).

In a 1967 study with New York Head Start children, the most effective measure for permanent improvement in nutritional status was the combining of parent and child nutrition education with the service of a nutritious meal (17). The same year a study was undertaken to evaluate the effectiveness of a questionnaire in determining the nutritional status of Head Start participants in the central United States (2). The validity of such methods is questioned as food quantities were not accurately recorded; but from this study, the results of an evaluation of the Head Start menu emerged. The percentage contributions of differing meal programs to total daily requirements are shown in Table 9. A greater percentage of total daily requirements of these children was supplied in the small city area,where lunch and a snack were served,than in the rural area that served only lunch or in the metropolitan area that served breakfast and a snack (2).

Louisiana Head Start Study (20, 21)

Since 1968 Tulane University Early Childhood Research Center and the School of Public Health and Tropical Medicine, under the sponsorship of the United States Office of Economic Opportunity, have been scrutinizing selected Head Start centers in the New Orleans area. While their main purpose was not to show improved nutritional status, researchers found that diet intervention improved the children's hemotocrit and hemoglobin values (20, 21). This ongoing study is worthy of close observation.

Mid-Western Industrial Town Head Start Study (13)

In a 1973 paper presented to the annual meeting of the Ambulatory Pediatric Association in San Francisco, Dr. A. Healy noted a correlation between participation in the Head Start Program and improved blood hemoglobin levels of children. From 1968 to 1972 he observed participation by a midwestern industrial town in the program. Late in 1969 nutritional supplementation and nutrition educational programs were initiated with resultant improvements in the originally low hemoglobin levels of the subjects (Table 10). Apparently, the original diets prevented maintenance of proper hemoglobin levels. Improvement in diet and the nutritional educational programs were responsible for the significant change in hemoglobin levels (13).

Santa Monica, California, Head Start Study (17)

In 1974 in Santa Monica, California, a study was undertaken to evaluate the social competence of Head Start children. Nutrition, although not the sole concern, was a consideration in this study. Interestingly, again with diet intervention and nutrition education, levels of hemoglobin and hemotocrit increased, thus denoting an improvement in iron status of the child (17).

Maine Head Start Study (8)

A very interesting comparison of Head Start children with nursery school children was conducted in Maine in 1976. Both groups were tested in the fall and then again in the spring. The diets of both groups were low in iron and high in protein. Growth patterns were similar for both groups. However, an increase in calcium and ascorbic acid was noted in the diets of the children who attended Head Start regularly. Heretofore,both these nutrients were below requirements. This improvement in nutritional status most probably resulted from the children's Head Start meals (8).

Table 9

Evaluation of the Menus from the Head Start Centers in the Three Areas Studied

	Small City (lunch and snack)		Rural (lunch only)		Metropolitan (breakfast and snack)	
Nutrient	Amount per day	Percent of day's requirement supplied	Amount per day	Percent of day's requirement supplied	Amount per day	Percent of day's requirement supplied
Calories	[illegible]	42.3	769.0	47.6	604.0	37.6
Protein (gm)	31.3	78.2	33.0	82.5	17.3	43.2
Calcium (mg)	665.0	83.0	382.0	47.7	359.0	44.9
Iron (mg)	3.6	36.0	4.4	44.0	3.2	32.0
Vitamin A (IU)	2767.0	110.0	3274.0	131.0	1322.0	52.8
Ascorbic Acid (mg)	87.6	175.0	44.0	88.0	47.0	94.0
Thiamin (mg)	.43	71.0	.38	63.3	.34	56.0
Riboflavin (mg)	.80	80.0	.78	78.0	.58	58.0
Niacin (mg)	7.45	67.8	5.86	53.2	3.1	28.0

Source: (2)

Table 10

Significant Changes in Blood Hemoglobin Levels

vs	1968	1969	1970	1971	1972
1968	-	NS	0.001*	0.001	0.001
1969	NS	-	0.001	0.001	0.001

*level of significance

Source: (13)

Contribution of the School Lunch Program to Total Nutritional Status

Studies from several states examined the contribution of the school lunch program to children's total nutritional status.

Contribution of School Lunch as Determined by the Ten-State Nutrition Survey (23, 24)

In conjunction with the Ten-State Nutrition Survey, 1968 to 1970, the value of the School Lunch Program on total nutritional status was investigated. A total of 8,495 children, ranging in age from ten to sixteen, from both low- and high-income ratio states were queried. Twenty-four-hour dietary recalls were collected for both school days and vacation days. The results showed that in both low- and high-income ratio groups the total daily intake of nutrients was greater in the group that ate the school lunch. The single exception was thiamin (as determined by urinary excretion), which, when the school lunch was consumed, was lower in the low-income ratio states. The greatest difference in meal nutrient intakes between the groups with or without school lunch was in relation to protein, calcium, and vitamin A.

Mean intakes were generally higher for the high-income ratio states, where the school lunch provided between twenty to forty percent of the total food intake. In the lower-income ratio states the percentage of total intake derived from the school lunch rose to thirty to fifty percent (23, 24). Figure 5 displays the comparison between the two groups investigated.

Investigation of School Lunch Program in Washington, D. C. (19)

From 1968 to 1974, the number of children in a selected Washington, D.C., group participating in the school lunch program increased from 20.6 to 24.9 percent. (From 2.7 to 9.4 percent received free lunches.) Although these researchers did not concern themselves primarily with discoveries about improvement in nutritional status, the results of the study yielded such data. The incidence of infectious diseases, even considering the increase in immunization, had so declined that an improved medical status was indicated, which in turn suggested improved nutritional state (19).

Investigation of School Lunch in California (9)

Realizing that the school lunch should provide approximately one-third of a child's recommended daily allowance of nutrients, C. A. Evans conducted an investigation of high school students from Alameda and Santa Clara Counties in California (9). The results showed that school lunches served at the high schools studied supplied sufficient amounts of nutrients, with the exception of iron and, in some instances, calcium. The nutrients, consumed varied from school to school, however. The total improvement in status in this study could not be assessed, as total daily intake was not a consideration (9).

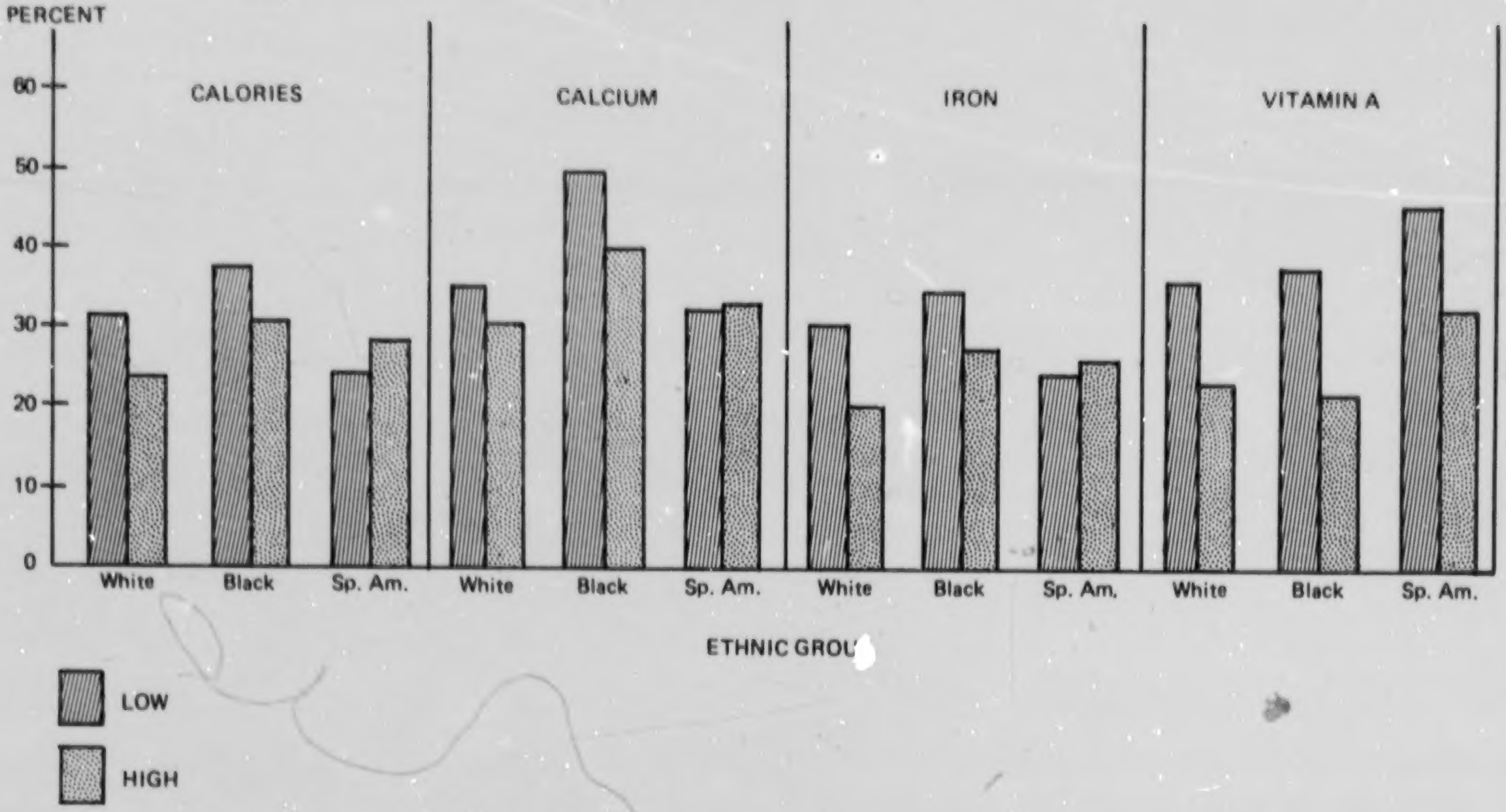


Figure 5

Percent of Selected Nutrients Contributed by School Lunches
for Children 10-16 Years of Age
in Low- and High-Income Ratio States

Source: (24)

Investigation of School Lunch in North Carolina (12)

In three sections of North Carolina, nutrient intakes of children eating school lunches were determined by subtracting the weight of plate waste from the amount of food served. The goal of the 1975 study was to see whether school lunches met one-third of the RDA. Laboratory analyses of food was used in this comprehensive study. Again, the nutrients most often falling below requirements were iron, calcium, vitamin A, vitamin C, and, in some instances, calories. The contribution to total status was not determined (12).

Investigation of School Lunch in Massachusetts (5)

Eighty thousand Massachusetts school children were surveyed in 1969 (5). Evidence of improvement in nutritional well-being was sought as a justification for the thousands of dollars spent on the program. The surveyed children were divided into the following groups:

Type of Lunch	Percent of Total
1. Bought the Type A lunch in school	52
2. Bought a la carte items in school	26
3. Brought lunch from home	7
4. Went home for lunch	8
5. Bought lunch in a neighborhood store	1
6. Did not eat lunch	6

On the survey day, sixty-four percent of the total surveyed purchased the Type A lunch, and, of this group, about three-fourths ate a satisfactory lunch (based on Type A lunch requirements). Results of the survey were tabulated as good, fair, satisfactory, poor, and no lunch. A "good" lunch was based on the Type A requirements. "Fair" or "satisfactory" classifications were applied to a lunch if a fruit, vegetable, or both were absent from the lunch.

On the survey day, fifty-three percent of the total queried group of children consumed a satisfactory (or better) lunch. The majority of satisfactory lunch eaters fell into the group that purchased the Type A lunch. "Value of the Type A lunch as it affects food intake of school children was shown readily by the survey" (5:30).

Conclusions

Studies cited have shown that where the dietary deprivation is the greatest, nutritional intervention makes the greatest contribution to total nutritional status. The English studies cited were particularly worthy of note because they not only measured amounts of the milk and lunch consumed, but they also considered these amounts in conjunction with the daily amounts of food eaten. Only in this light does nutritional intervention contribute to total status. The Ten-State Nutrition Survey attempted this procedure, but more accurate records of actual food intake are necessary if a more complete picture of nutritional status is desired. More recent studies are now measuring nutritional intervention feedings with greater precision. Incorporation of these results with a child's total daily intake will give a more accurate picture of the value of supplemental feeding as a measure of improving total nutritional status. From the results of studies cited above a general principle emerges: The provision of dietary supplementation to a child whose nutritional status was formerly "at risk" will in reality improve the well-being of the child.

Bibliography

1. A Complete Summary of the Iowa Breakfast Studies. Chicago, Ill.: Cereal Institute, Inc., September 1962; reprint ed., Chicago, Ill.: Cereal Institute, Inc., January 1976.

2. Bass, W., and others. Head Start Evaluation and Research Center, University of Kansas. Report No. VIII, Physical Development of Children in the Head Start Program in the Central United States. ERIC Document ED 021 644, November 1967.

3. Bender, A. E., P. Magee, and A. H. Nash. "Survey of School Meals," British Medical Journal, 2 (No. 5810) (May 1972), 383-385.

4. Bureau of Child Nutrition Services. California Child Nutrition Programs-Policy and Procedure Handbook. Sacramento: California State Department of Education, 1977.

5. Calahan, D. L. "You Can't Teach a Hungry Child," School Lunch Journal, 25(3) (March 1971), 26-42.

6. Cook, J., D. G. Altman, A. Jacoby, and W. W. Holland. "School Meals and the Nutrition of Schoolchildren," British Journal of Preventive and Social Medicine, 29(3) (September 1975), 182-189.

7. Cook, J., D. G. Altman, A. Jacoby, and W. W. Holland. "The Contribution Made by School Milk to the Nutrition of Primary Schoolchildren," Journal of Nutrition, 34(1) (July 1975), 91-103.

8. Cook, R. A., and others. "Nutritional Status of Head Start and Nursery Schoolchildren," Journal of the American Dietetic Association, 68(2) (February 1976), 120-126.

9. Evans, C. A. "The Effectiveness of Type A Lunch Programs in Improving Student Nutrition in Selected High Schools, Alameda-Santa Clara Counties, California." Unpublished thesis manuscript, San Jose State University, 1975.

10. Francies,H., and M. Fleming. Nutritional Improvement Project, Educational Resources Information Center, ERIC Document ED 078 103, March 1973.

11. Frankle, R. T., M. F. Senhouse, and C. Cowell. "Project Head Start - A Challenge in Creativity in Community Nutrition," Journal of Home Economics, 59(1) (January 1967), 24-27.

12. Head, M. K., and R. J. Weeks. "Major Nutrients in the Type A Lunch." "Amounts Consumed by Students," Journal of the American Dietetic Association, 67(3) (October 1975), 356-360.

13. Healy, A. "The Influence of Nutritional and Educational Programs on Hemoglobin Values in a Head Start Population Over a Five-Year Period." Paper presented at the 13th Annual Ambulatory Pediatric Association Meeting, San Francisco, California, May 16, 1973.

Bibliography (Continued)

14. Orshansky, M. Children of the Poor. Social Security Bulletin, U. S. Department of Health, Education, and Welfare, July 1963.

15. Paige, D. M., and G. G. Graham. "School Milk Programs and Negro Children: A Nutritional Dilemma," The Journal of School Health, 44(1) (January 1974), 8-10.

16. Perryman, J. N. The School Administration and the Food Service Program. Washington, D.C.: National Association of Elementary School Principals, National Education Association, 1972.

17. Raizen, S., and others. Design for a National Evaluation of Social Competence in Head Start Children. Santa Monica: Rand Corp., ERIC Document ED 104 569, November 1974.

18. Richardson, D. P., and M. Lawson. "Nutritional Value of Midday Meals of Senior Schoolchildren," British Medical Journal, 4 (No. 5842) (December 1972), 697-699.

19. Snapper, K. J., and others. The Status of Children 1975, George Washington University, Washington, D. C. Social Research Group. Sponsoring Agency: DHEW Contract No. HEW - 100 - 75 - 0010. ERIC Document ED 129 429, 1975.

20. Sulzer, J. L., W. J. Hansche, and F. Koenig. "Nutrition and Behavior in Head Start Children: Results from the Tulane Study." Nutrition, Development and Social Behavior. Ed. David J. Kallen. Washington: U. S. Government Printing Office, 1973.

21. Sulzer, J. L. Behavioral Data from the Tulane Nutrition Study. Tulane University, New Orleans, Louisiana. Paper presented at the meeting of the American Association for the Advancement of Science, Boston, Massachusetts. ERIC Document ED 043 375, December 1970.

22. The Food Research and Action Center. "If We Had Ham, We Could Have Ham and Eggs. . . If We Had Eggs." A Study of the National School Breakfast Program. New York: Gazette Press, Inc., 1972.

23. U. S. Center for Disease Control, Atlanta, Ten-State Nutrition Survey, 1968-1970, DHEW Publiation No. (HSM) 72-8133, 1972.

24. U. S. Center for Disease Control, Atlanta, Ten-State Nutrition Survey, 1968-1970, DHEW Publication No. (HSM) 72-8134, 1972.

CHAPTER 5

General Contributing Factors in Nutritional Status

In essence, what a person eats determines his or her nutritional status. However, many factors directly and indirectly influence that choice of food. In this section, the influences upon one's food selections and methods of improving these choices will be discussed. The success that has been achieved in these endeavors will be reviewed.

Environmental and Cultural Factors

Environmental factors are classified as physical, biological, and social. Water, soil, and air comprise the physical surroundings, whereas viruses, bacteria, and parasites comprise the biological environment. Social environment evolves from tradition, beliefs, and forms of social organization (25). These three factors are interwoven, and to separate them is often impossible. Nutritional status is closely intertwined with these three factors. In fact, except for disease, all factors influence man through food (27). Figure 6 is a schematic drawing which shows how culture, economics, education, and climate influence man through food and how disease acts directly on man. In the developing countries any and all of these factors have a profound effect on the nutritional status of individuals and groups. The quality of life in these countries must be improved to eradicate infection, poverty, and malnutrition (27).

In the more developed countries, the United States included, a different approach is necessary if nutritional science is to continue to grow and produce favorable effects. Nutritional behavior must be viewed as an inseparable part of one's life-style. Man has advanced in his nutritional behavior from the era when availability of food governed his diet to the point where food resources, cultural values, and knowledge of and responsibility to his species govern his nutritional habits (20).

Americans exhibit no gross, severe types of malnutrition as revealed by the status survey reviews presented earlier in this text (pp. 5, 8, 13, 14, and 17). However, there are chronic, long-standing instances of under- and overnutrition.

The physical well-being of the population determines a nation's sociological health and economic growth. As Figure 6 shows, proper nutrition is the prime determinant of physical well-being. Formerly, nutritional status was correlated only with personal preference and expenditure, but now food availability and prices also have a big impact on dietary habits. Economics then has a bearing on man's nutritional status (16).

Effect of Nutrition Education

Studies on the effects of nutrition education programs reveal an improved nutritional status of participants in these programs. The need to inform future generations of the discoveries from this relatively new science justifies the need for nutrition education programs.

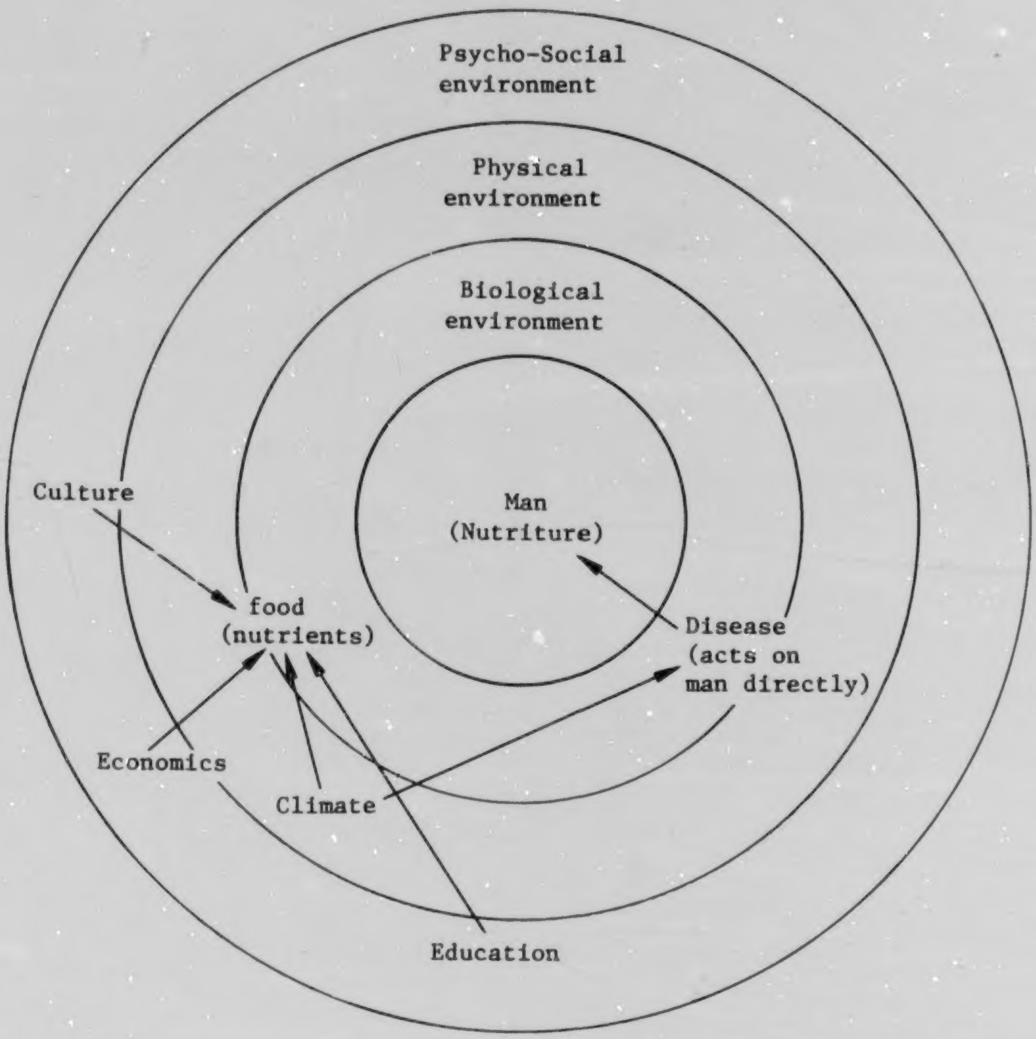

Psycho-Social environment
Physical environment
Biological environment
Man (Nutriture)
Culture
food (nutrients)
Disease (acts on man directly)
Economics
Climate
Education

Figure 6

The Effect of Environment on
the Nutriture of Man

Source: (27)

Need for Nutrition Education

The United States has been considered a nation of nutritional illiterates because the American people have not kept pace educationally with the acquisition of nutritional data (38). There is a need for nutrition education because each new generation must be taught to use the available food supply sensibly and also because nutrition is a "new" science, whose body of data is constantly expanding (39). The federal government recognizes that nutritional education is vital to improved national nutritional status as the following quote from the Child Nutrition Act of 1966 reveals:

> Cash Grants for Nutrition Education
>
> Section 18. (a) The Secretary is hereby authorized and directed to make cash grants to State educational agencies for the purpose of conducting experimental or demonstration projects to teach schoolchildren the nutritional value of foods and the relationship of nutrition to human health.
>
> (b) In order to carry out the program, provided for in subsection (a) of this section, there is hereby authorized to be appropriated not to exceed $1,000,000 annually. The Secretary shall withhold not less than 1 per centum of any funds appropriated under this section and shall expend these funds to carry out research and development projects relevant to the purpose of this section, particularly to develop materials and techniques for the innovative presentation of nutritional information. (35:35)

A 1977 amendment to the Child Nutrition Act of 1966, entitled "Nutritional Education and Training," points to the school lunch and child nutrition programs as the means through which nutritional knowledge can be disseminated to children and, through them, to their parents. The aim of the amendment is to change poor dietary habits and thus to improve the nutritional status of all (36).

The following reasons given by Philip L. White, the President of the Society for Nutrition Education, reveal the importance of nutrition education:

1. To equip one to make judicious food choices for health and well-being. Good nutrition is vital to the achievement of one's genetic potential.

2. A good knowledge of nutrition is essential for the maintenance of health, especially when food habits temporarily or permanently deteriorate--as in dieting, illness, old age and poverty, and when an educational base might fail leading to "faddish" experimentation.

3. Food and nutrition education is necessary for saving money and avoiding waste. In essence, nutrition education relates scientific knowledge to the total strategy for survival.

4. Nutrition education is a base for the evaluation of food and nutrition information, both good and bad.

5. Nutrition education can be of great benefit to those in the lowest economic stratum. While not as important as financial resources, nutrition education can equip the people who find themselves economically deprived to make the most expeditious use of financial resources.

6. Nutrition education is essential to reinforce or correct family teaching about food and nutrition. (38:54)

Target Groups for Nutrition Education Programs

To change a person's food habits is a complex undertaking requiring long periods of time. The age of the learner and the interest and enthusiasm exhibited by the teachers also influence one's ability to change food habits (39). Through the years, nutrition educators have used different groups of individuals of various ages as their target groups.

Preschoolers. Many educators feel strongly that nutrition education should begin with the preschool child. In Philadelphia at a community area in a shopping plaza, informal nutrition education was extended to the preschoolers who accompanied their mothers to the plaza. Storytelling was the medium used to impart this knowledge. The children exhibited keen interest, and the mothers also showed much enthusiasm for this ingenious method. However, there was no means to evaluate the effectiveness of this program (18).

In San Francisco an attempt was made to provide nutritional instruction to the preschool child in the day care center (17). The shared meal at the center, consisting of attractive, well-balanced meals, was the method used to instruct these youngsters in proper dietary habits. While permanent improvement in dietary habits was not apparent, this program attempted to form a good solid nutrition foundation upon which later nutrition education could be built (17).

The Expanded Food and Nutrition Education Program (EFNEP) tried to improve the nutritional status of infants by incorporating a nutrition aide as part of the staff at a well-baby clinic (4). The aide's role was to reinforce nutritional advice given to the mothers. Although no statistical benefits were noted, the concept was considered beneficial in the light of the following three points:

1. Reduction in the practice of introducing whole cow's milk to young infants

2. Increase in wider varieties of foods given to older infants

3. Reduction in the prevalence of iron-deficiency anemia (4)

Mothers. The next target group to be considered is the mothers. In Montana, the mothers in Head Start families were chosen as subjects for nutrition education. Positive changes in both attitudes and food practices were noted when the program was initiated (40). The same results were noted for nutrition education programs given in the developing countries of Guatemala and Haiti. If the quality of the nutrition education was poor or the father's ignorance of nutrition was severe, then the education of the mothers showed no positive results (2). A later study in Haiti showed that, after their mothers completed the program, children exhibited improved status, as measured by their optimum weight gains in comparison with children whose mothers had not received nutrition instruction (37).

In India, nutrition education was undertaken to improve nutritional status (10). Here, the mothers and the young children received education in conjunction with supplementary feeding. The results of the study showed that, when education accompanied the feeding, the positive results, as evidenced by improved nutritional status, were the greatest (10).

A nutrition education program in California chose as its target group mothers involved in the Special Supplemental Foods for Women, Infants, and Children Program (WIC) (12). The researchers found the most effective nutrition education method was the distribution of free food vouchers along with brief informational materials accompanied by verbal explanation. As a result of this educational attempt the research team thought that benefits would be noted in later status studies (12).

Physicians and Nurses. Since proper nutrition determines physical health, any part of the health-care team must have a knowledge of correct nutritional data. The necessity of nutrition classes as an integrated part of a physician's training is noted (8, 9, 31). Current nutritional data must also be incorporated into a nursing curriculum in a meaningful way. Hopefully, the correct nutritional attitudes, skills, and practices of the nurse are reflected in the patients she serves (34).

Teachers and Food Service Personnel. Since teachers and food service personnel are part of the environment responsible for teaching children, these two groups must be in possession of proper nutritional information. "As teachers serve as image models and behavioral change agents, they should be provided with resource information and training in nutrition education" (33:23). The state of Maryland proposed the following recommendations for teachers:

> Recommendation No. 8
>
> Introduce pilot nutrition education courses in selected undergraduate training programs which train early childhood and primary school teachers.
>
> Recommendation No. 9
>
> Make available preservice and in-service programs and contributing education courses to all teachers in grades K-12 to enable them to acquire a knowledge of nutrition subject matter, nutrition education methodology, and community nutrition resources.

Recommendation No. 10

Require all elementary teachers to have a course in basic nutrition. (33:24)

The state of California also recognized the need as described by Perryman in the following quote:

> A school food service program that provides only food for the student--no matter how successfully--is failing in its role as a part of an educational program. It is both the function and the obligation of the school food service program to be a source of nutritional information to the student, the school, and the community. (28:13)

In an attempt to satisfy this need, the Child Nutrition Facilities Act of 1975 was generated in California (7). The aim of this act was to provide one nutritionally adequate meal per day and also, with the long-range purpose of improving food habits, health, and productivity, to instruct children from all income levels in the principles of good nutrition. The funding for nutrition education projects was appropriated at the level of 2 percent from state school meal reimbursements. The curriculum for the project includes classroom instruction based on a multidisciplinary approach (prepared by the food service nutritionist and administered by the classroom teacher). The food service nutritionist is also responsible for preparing instruction sessions for school staff and parents. The whole program is channeled through the school food service (7).

The method used in evaluating the results consisted of a pre- and post-test for students, school staff, and parents. The test included cognitive and affective components. Plate-waste data are collected for the project students who are participating in the school lunch program on a pre- and post-test basis. Plate-waste data for a group of students not receiving nutrition education are also collected and comparisons made (11). Seventeen schools (11) participating in the project in the 1976 and 1977 school year evidenced the following results:

1. Decrease in plate-waste

2. Increase in knowledge of basic nutrition concepts as evidenced by an increase in post-test scores over pretest scores

3. Increase in positive attitude toward food as evidenced by affective test score increase

4. Increase in understanding of nutritional concepts by the staff as evidenced by increased scores on post-test over the pretest in both the cognitive and affective portions of the test

Parents exhibited the weakest gains, but they too evidenced increases on the post-test over the pretest on both cognitive and affective portions of the test (11).

For the school year 1977 and 1978 the following schools were included in the project (7):

Participating Child Nutrition Entities (1977-78)

Bakersfield College
Benicia Unified School District
Berkeley Head Start
California State University, Los Angeles
Chinatown Community Children's Center
Contra Costa County Department of Human Resources
Chula Vista City School District
East Long Beach Neighborhood Center
Humboldt County Superintendent of Schools
Lamont Elementary School District
Mendocino County Superintendent of Schools
Milpitas Unified School District
Newport-Mesa Unified School District
Oakland Unified School District
Old Adobe Elementary School District
Placer County Office of Education
Poway Unified School District
Riverside Unified School District
Rowland Unified School District
San Diego City Schools
San Francisco Head Start
San Jose Unified School District
San Juan Unified School District
San Ramon Valley Unified School District
San Mateo City Schools
Santa Barbara City Schools
Santa Clara Unified School District
Shasta High School District
Tribal American Children's Center
Vallejo Unified School District

Students. The Dairy Council of California studied the effect of nutrition education on the students and teachers at the second-grade level in the Los Angeles area (22). The study was divided into three phases. The first phase, called the Nutrition Teaching Environment Study, showed that although there is an awareness of the four food groups among second-grade teachers, less than half were able to select a balanced meal. The second phase was called Experimental Teacher Group Training. Pretesting, followed by two days of nutritional instruction, followed by a post-test showed an increase of 69 percent on the average grade on the post-test. The third phase was called Student Nutrition Test-Teach-Test Program. In this phase a 76 percent increase in the average score on a test of nutritional knowledge was noted (22). This increase suggests that the teachers' instructional techniques about nutrition became more effective following their nutrition training sessions.

In Little Rock, Arkansas, nutrition education programs were undertaken with two groups of primary-grade children (3). The material to be presented to the children was prepared by the nutritionists from the school food service department and was presented to the children by the classroom teacher. The variable was that for one group of teachers, an assistant nutrition coordinator, supplemental teaching materials, as well as supplies and suggestions (from the food service department) were provided, while the other group of teachers was unaided. Changes in children's eating habits and behavior toward food occurred more readily when food service department assistance reinforced teacher instruction.

A four-week study in suburban Maryland (5) tested a sample of thirty second graders following a thirty-minute daily nutrition instruction session. A nutrition post-test, plate-waste observation, and parent-prepared questionnaires following instruction were used to evaluate the effectiveness of the program. While results were not startling, there seemed to be a trend toward improved dietary habits. This study stressed the importance of the home in influencing dietary habits (5).

The effectiveness of a three-week nutrition teaching unit on fourth and fifth graders in Iowa (1) was undertaken. The results were to be measured by changes in nutritional attitude, dietary habits, and nutritional knowledge among the two hundred youngsters who were involved in this program. While this study noted an increase in nutritional knowledge, no dietary habit changes occurred. The significance of this study lies in the methodology of the experiment, which provided valuable guidelines for research in the field of nutrition education (1).

Even though major emphasis had been placed on nutrition education in the previous school years, the Tennessee Health Education Project (19) was initiated in 1972 to solve the problem of high school students' poor nutritional habits. This project attempted to incorporate nutrition education into the different health content areas in the high school curriculum. A trend toward incorporating nutrition education into the total health care instruction unit is emerging (19).

A minicourse in food and nutrition was developed at the Massachusetts Institute of Technology. "The minicourse. . . is used here to mean a short, complete course which can stand on its own or serve as an independent unit in a longer course" (30:25). Once the value of the teaching method was established, a trial course was administered to eleventh and twelfth graders from the Boston area. Pre- and post-tests were administered to both the test and the control groups before and after the minicourse. To evaluate changes in knowledge, attitudes, and behavior concerning nutrition was the program objective. A significant improvement occurred in the acquisition of nutrition knowledge, but no change appeared in attitude and behavior (29). These minicourses were often incorporated into the chemistry and biology curriculum.

In Illinois a researcher attempted to instruct high school students by using games and "discovery learning" techniques (32). The outcome of this type of education showed increases in nutrition knowledge and an improvement in attitudes toward nutrition. A tentative conclusion would be that by varying teaching techniques one could improve student knowledge of and attitudes toward nutrition (32). In this study nutrition was taught apart from related science courses.

Community. In a Nashville, Tennessee, project a low-income community was used as the target area (15). The community consisted of 453,500 households from an inner-city, black, deprived, low-income area. The techniques and approaches used are as follows:

1. Involving people in a self-help type program of nutrition improvement
2. Increasing access to food in a community by various means which included the transportation to food stores for those who had no means of transportation
3. Increasing the utilization of, and participation in, various supplemental food programs as well as the Food Stamp Program by eligible persons
4. Intensive education activities at the project site, at the site of purchase, as well as in the homes and various places in the community
5. Providing the consumer group with different ways and means of obtaining more, better and different kinds of foods and thereby improving the nutritional status of individuals and the quality of their lives
6. Centering all of these activities around a core community nutrition group with volunteers from the community and the colleges, particularly Fisk, Tennessee State and Vanderbilt Universities, as well as Meharry Medical College (15:464)

The researcher stressed that good nutrition practice and good health care go hand-in-hand. The biochemical analyses performed before the initiation of the program and fifteen months afterward showed improvement in the subjects' nutritional status, as measured by serum levels of ascorbic acid, iron, and folic acid, and in urinary riboflavin and thiamin. No change was noted in plasma vitamin A content. These results point to the effectiveness of this program in improving over-all nutritional status (15).

In Chicago (21), nutrition education was integrated into the interdisciplinary health care services. The medical group aimed to incorporate nutrition counseling as a necessary part of ambulatory health care organizations and thus used preventive methods to improve nutritional health (21).

Effect of Mass Media on Nutritional Status

One of the most powerful techniques for satisfying the needs of nutritional education is the mass media, whose advertisements and commercials are potent teaching devices. Nutrition educators must use this tool to improve the nutritional status of children and adults alike (23).

Numerous nutritional messages appear on children's television, but they do not encourage proper dietary habits. Some of the television commercials are misleading and confusing to the children. Yet, these messages bombard children daily. Thus, a perfect, mostly untapped, opportunity to teach correct dietary habits is being overlooked (13). One company that is taking advantage of this opportunity is Sunkist, whose commercials successfully teach good nutritional habits.

Radio is used in Korea to reach the people and provide proper, current, nutritional data (14). The Koreans also devised a nutritional calendar to inform their population about nutrition (14). In Korea as well as the United States, comic strips about nutrition have been used in an attempt to catch the interest of people (14, 24). Another ingenious use of media was a nutritional musical created by two very talented, concerned students in an attempt to deliver the "good news" of proper nutrition to many people (26).

Conclusions

As Figure 6 shows, economics and education constitute human intellectual areas that mutually affect the nutriture of the population section classified as "mildly malnourished." For example, the poor, no matter how much nutrition education they receive, will continue to be malnourished as long as they do not have sufficient funds to purchase proper food. On the other hand, nutritional status studies reveal that while malnutrition is most often associated with poverty, evidences of deficiencies appear in all segments of our society. Therefore, proper education, even with limited funds, should improve nutritional health. Although only the Tennessee project measured status before and after nutrition education, a general assumption is that any improvement in dietary habits will be eventually reflected in improved status.

Both the incorporation of nutrition education into the curriculum of other disciplines and the adoption of forceful teaching techniques have met with success in the search for the proper way to teach nutrition. The conclusions of the California Education Projects emphasize that the incorporation of nutrition education into the school curriculum is a successful practice. As to which particular segment of humanity is most receptive to nutrition education, a definite answer cannot be given, because all groups given nutrition instruction improved their dietary habits. Ideally then, in order for nutrition education to be effective in improving nutritional status, the most effective techniques, enthusiastic teachers, and interested and receptive groups must be combined.

To quote from George M. Briggs:

> . . . it cannot be disputed that nutrition education is able to influence the eating habits of populations. It depends on the message, how well it's done, the target population, and how much money and time are available to do the job. (6:52)

He encourages all to speak up and to support and develop more effective nutrition education programs and more nutrition education research, which will ultimately produce a healthier United States population (6). When success is realized in the field of nutrition education, improvement in nutritional status of the people will be evidenced in the United States.

Bibliography

1. Baker, M. J. "Influence of Nutrition Education on Fourth and Fifth Graders," Journal of Nutrition Education, 4(2) (Spring 1972), 55-58.
2. Beaudry-Dariume, M. "Nutrition Rehabilitation Center - An Evaluation of Their Performance," Environmental Child Health, 19(3) (September 1973), 299-332.
3. Blakeway, S. F., and M. E. Knickrehm. "Nutrition Education in the Little Rock School Lunch Program," Journal of the American Dietetic Association, 72(4), (April 1978), 389-391.
4. Bowering, J., and others. "Influence of a Nutrition Education Program (EFNEP) on Infant Nutrition in East Harlem," Journal of the American Dietetic Association, 72(4) (April 1978), 392-397.
5. Boysen, S. C., and R. A. Ahrens. "Nutrition Instruction and Lunch Surveys with Second Graders," Journal of Nutrition Education, 4(4) (Fall 1972), 172-175.
6. Briggs, G. M. "Effectiveness of Nutrition Education," Journal of Nutrition Education, 9(2) (April-June 1976), 52.
7. California State Department of Education, Nutrition Education Fact Sheet, Wilson Riles, Superintendent of Public Instruction, Sacramento, California, July 7, 1977.
8. Christakis, G. J. "Teaching Nutrition in the Medical School," Journal of Nutrition Education, 4(3) (Summer 1972), 141-145.
9. Cyborski, C. K. "Nutrition Content in Medical Curricula," Journal of Nutrition Education, 9(1) (January-March 1977), 17-18.
10. Devadas, R. P., and others. "Studies on Special Nutrition Programme (SNP) IV. Effectiveness of a Nutrition Education Programme Among the Beneficiaries of SNP," The Indian Journal of Nutrition and Dietetics, 14 (1977), 227-230.
11. Evaluation of 1976-1977 Nutrition Education Projects, Assessment Results, Summarized by H. K. Wolff, California State University, Chico, California, April 6, 1978.
12. Gaman, E. "A WIC Pilot Program with Nutrition Education," Journal of Nutrition Education, 9(4) (October-December, 1976), 157-158.
13. Gussow, J. "Counternutritional Messages of TV Ads Aimed at Children," Journal of Nutrition Education, 4(2) (Spring 1972), 48-52.
14. Higgins, M., and J. Montague. "Nutrition Education through the Mass Media," Journal of Nutrition Education, 4(2) (Spring 1972), 58-62.

Bibliography (Continued)

15. High, E. G., and others. "The Impact of a Community Nutrition Program on the Nutritional Status of an Urban Population Group," Journal of the National Medical Association, 68(6) (November 1976), 461-466.

16. Jolly, D. A. "Food Cost, Farm Policy and Nutrition," Journal of Nutrition Education, 8(2) (April-June 1976), 56-58.

17. Juhas, L. "Nutrition Education for Young Children in Group Care." Proceedings of the Ninth International Congress of Nutrition, Mexico, 1972. Eds., A. Chavez, and others. Muchen, Paris, London, New York, and Sydney: S. Karger-Basel, 1975.

18. Kershner, M. H., and N. S. Storz. "Nutrition Education for Preschoolers at the Shopping Mall," Journal of Nutrition Education, 8(4) (October-December 1976), 168.

19. Kirk, R. H., M. Hamrick, and D. C. McAfee. "Nutrition in Health Instruction: The Tennessee Health Education Project," Journal of Nutrition Education, 7(2) (April-June 1975), 68-71.

20. Krondl, M. M., and J. Welsh. "Toward a Dynamic Technology of Nutrition Behavior." Proceedings of the Ninth International Congress of Nutrition, Mexico, 1972. Eds., A. Chavez, and others. Muchen, Paris, London, New York, and Sydney: S. Karger-Basel, 1975.

21. Kunis, B. S. "Family Nutritionist on the Primary Health Care Team," Journal of Nutrition Education, 8(2) (April-June 1976), 77-79.

22. Lovett, R., and others. "The Effect of a Nutrition Program at the Second Grade Level," Journal of Nutrition Education, 2(2) (Fall 1970), 79-95.

23. Manoff, R. K. "Potential Uses of Mass Media in Nutrition Programs." Proceedings of the Ninth International Congress of Nutrition, Mexico, 1972. Eds., A. Chavez, and others. Muchen, Paris, London, New York, and Sydney: S. Karger-Basel, 1975.

24. Mapes, M. C. "Gulp - An Alternate Method for Reaching Teens," Journal of Nutrition Education, 9(1) (January-March 1977), 12-16.

25. Mata, L. J. "The Environment of the Malnourished Child," Basic Life Sciences, 7 (1976), 45-66.

26. McCauley, J., and M. Smith. "Vegetebella - A Nutrition Musical for Young and Old," Journal of Nutrition Education, 9(1) (January-March 1977), 18-19.

27. McLaren, D. S., ed. Nutrition in the Community. London, New York, Sydney, and Toronto: John Wiley and Sons, 1976.

Bibliography (Continued)

28. Perryman, J. N. The School Administrator and the Food Service Program. Washington, D.C.: National Association of Elementary School Principals, National Education Association, 1972.

29. Picardi, S. M., and D. Porter. "Multidimensional Evaluation of a Food and Nutrition Minicourse," Journal of Nutrition Education, 8(4) (October-December 1976), 162-168.

30. Picardi, S. M., and E. R. Pariser. "Food and Nutrition Minicourse for 11th and 12th Grades," Journal of Nutrition Education, 7(1) (January-March 1975), 25-29.

31. Robinson, L. G., and A. H. Paulbitski. "Nutrition Seminar for Physicians," Journal of Nutrition Education, 4(4) (Fall 1972), 176.

32. Spitze, H. T. "Curriculum Materials and Nutrition Learning at the High School Level," Journal of Nutrition Education, 8(2) (April-June 1976), 59-61.

33. State of Maryland, Report of the Food Services Task Force on Joint Resolution No. 63, March 15, 1976.

34. Trooboff, R. C. "Integrating Nutrition into the Nursing Curriculum," Journal of Nutrition Education, 4(2) (Spring 1972), 62-66.

35. U. S. Senate, Select Committee on Nutrition and Human Needs. Compilation of the National School Lunch Act and The Child Nutrition Act of 1966. Washington: Government Printing Office, 1976.

36. U. S. Senate Report, National School Lunch and Child Nutrition Amendments of 1977, 95th Congress 1st Session, No. 95-504, 1977.

37. Webb, R. E., W. Fougere, and Y. Papillon. "An Evaluation of the Educational Benefits of Nutritional Rehabilitation Centres as Measured by the Nutritional Status of Siblings," Environmental Child Health, 21(1) (February 1975), 7-10.

38. White, P. L. "Why All the Fuss Over Nutrition Education?" Journal of Nutrition Education, 8(2) (April-June 1976), 54.

39. Whitehead, F. E. "Nutrition Education Research," World Review of Nutrition of Dietetics, 17 (1973), 91-149.

40. Zimmerman, R. R., and N. Monro. "Changing Head Start Mothers' Food Attitudes and Practices," Journal of Nutrition Education, 4(2) (Spring 1972), 66-68.

CHAPTER 6

Malnutrition and Obesity

Dietary patterns of greater food intake than required and of high-calorie food consumption are major causes of obesity, which often impairs a child's physiological and psychological well-being.

Prevalence in Children

In affluent societies, such as the United States, obesity is becoming an ever increasing and serious health problem. Excessive weight has been declared the most common nutritional disorder among school children in our society (11). Obesity has also been considered a symptom rather than a disease, such as high blood pressure or anemia. To be overweight represents a visible consequence of ingesting more calories than are being consumed as energy (1).

Accurate figures about the number of obese children are not available because of difficulties in defining and measuring excessive weight. However, various studies have attempted to approximate the magnitude of the problem of obesity in children.

A study conducted in Hawaii among preschool children revealed that 5 to 10 percent of two- to three-year olds were considered fat (13). In the Ten-State Survey, which used the data from the California component, 14 percent of the children under six years of age had weights above the 84th percentile values of the Iowa standards (15). Also in the Ten-State Survey information on skinfold data from the Ten-State Survey revealed that 5 to 7 percent of the children in the three- to six-year age group had values above the 95th percentile (15).

In school-age children, the prevalence of overweight continues. According to Neumann (15), 3 to 20 percent of these children are described as obese, depending on the particular groups examined and the definitions, methods, and standards used to describe obesity. In a Cincinnati study that used tricep skinfold measurements, 10 percent of the school children were described as obese (15). Another group of high school students from Berkeley, California, was examined for obesity. Eleven percent of the ninth graders and 14 percent of the twelfth graders were considered obese (10).

In an English study using weight-for-height definitions, obesity among school children, aged six to fourteen years, was 2.7 percent. However, in another English study of the same age group,using trifold skin thickness as a measurement (20mm or greater), a higher incidence was revealed. In a group of nine-year olds, 11.2 percent of girls and 3.5 percent of boys were so classified (6). Other English studies showed a 2 to 5 percent obesity factor in school children up to the age of puberty (11). But a remarkable increase to 30 percent in fourteen-year-old girls was revealed in a study by Lloyd in Buckinghamshire (11).

More investigators have cited a more general statistical range, from 10 to 20 percent, for the prevalence of obesity in high school students (5, 13, 14, 18). And yet another reflection of the prevalence of obesity might be evidenced by studies showing that in the last fifty years, American boys have become 6 to 8 percent taller and 12 to 15 percent heavier than their fathers (10).

Determination of Obesity

Statistics describing the prevalence of obesity among children mean little without some explanation of the determination of overweight. Obesity refers to excess fat on the body, but there is no specific amount of fat which classifies the individual as obese (11).

To measure the total quantity of body fat is not easy. Determination by weight, the most common method, is only a rough guide to obesity, even when the child's sex, age, and height are considered. This method does not reflect the contribution to overweight caused by fat as distinct from muscle and bone (11). Not all heavy children are obese, although children whose weight exceeds the standard for height, age, and sex by more than 20 percent are likely to have too much fat (11).

Another way to measure body fatness, sometimes considered simpler and more effective, is the use of calipers. The fat fold under the skin at either the upper arm (triceps) or subscapula is grasped with the calipers. A measurement is taken and compared with existing standards of normal ranges for boys and girls (10, 11). In practice the gauge of obesity by simple inspection (11) is an easier method to use. A knowledgeable observer, seeing a child undressed, can usually make a fair assessment of excess fatness; so, as a general principle, if a child looks fat, then he or she is obese (11, 14).

Causation of Obesity

While establishing the prevalence of obesity in children, researchers have found it necessary to investigate some of the causes of this health disorder. Since obesity in childhood, as in any other age group, is not a uniform condition, there are a number of contributing factors in causation (2). According to Lloyd:

> Strictly speaking, there is only one cause of obesity, namely, an intake of energy in the form of food which is in excess of the child's requirements (including the requirements for growth and activity) and the subsequent storage of surplus energy in the form of fat. (11:11)

Heredity has also been found to play a part in determining body fatness. Studies in Massachusetts show that in families where both parents are of normal weight, less than 10 percent of their children will be obese. Yet if one parent is obese, 40 percent of their offspring will be obese, and the increase will be to 80 percent if both parents are obese (14). In a study by Matsuno, Hankin, and Dickinson (13), of eleven families of obese children in Hawaii, obesity was prevalent in eight mothers and five fathers.

The same propensity is not seen in studies of adopted children, who were adopted when they were very young (10). Studies of identical and fraternal twins, some of whom were raised in different households, show results supporting the genetic predisposition for obesity (14).

Fatness beginning in infancy also shows a correlation with obesity in older children. The study by Cheek and White (5) suggests that overnutrition during infancy is common and capable of promoting the excess secretion of hormones, such as growth hormone and insulin in individuals with a genetic susceptibility. The data indicate that the practice of increasing food intake during infancy may initiate excessive hormone activity and excess growth of fat tissue as well as lean body mass (5).

Stunkard (16) agrees with the theory that the number of the cells in fat tissue is determined very early in life and that overeating during this critical early period gives rise to fat tissue containing a large number of fat cells. He further states that after childhood, any increase in body fat is achieved by an increase in the size, not the number, of individual cells. Neumann (15) agrees that childhood obesity often starts in infancy, but he feels a more common onset occurs probably in the mid-childhood years. The seriousness of onset in mid-childhood years is supported by correlating data on obesity in the school-age child with persistence of obesity in later life.

Socioeconomic Factors

The children from low-economic groups are considered to be a vulnerable and high-risk group for obesity. In a study conducted by Stunkard and others (17), 3,344 inner-city children were evaluated with the use of triceps skinfold measurements of 23 mm. in females and 18 mm. in males, as the definition of obesity. The results showed that nine times greater prevalence of obesity occurred in girls from lower rather than higher socioeconomic levels. In boys, great differences also appeared by age six; lower-class boys had twice the prevalence of obesity as those from higher classes. The poor showed a greater trend toward obesity during childhood and into late adolescence. However, based on the Ten-State Nutrition Survey, Garn and Clark (9) found that, until adolescence, children from higher socioeconomic groups were consistently fatter (as measured by triceps skinfold) than those in lower-income levels. In the upper-income groups, the degree of fatness was highest in earlier childhood.

Problems an Obese Child Encounters

The problems which the obese child encounters are mainly concentrated in the adolescent period. However, the obese pre-adolescent is not carefree, because the complexities of obesity, both physiological and psychological, are magnified during these years of development (14).

Physical Problems

Since obesity is a nutritional disorder of the body, certain physiological manifestations are expected. Many of these, such as heart disease and high blood pressure, do not appear until later in life. There are some serious, but rare, diseases associated with obesity that can develop during childhood. An example is Pickwickian syndrome, a condition involving carbon dioxide narcosis and decreased ventilatory capacity (15). Other results of severe overweight cause certain orthopedic disorders, such as Legg-Perthes disease and genu valgum (15).

More common physical complaints associated with childhood obesity are in the form of clumsiness, shortness of breath, skin irritation due to friction, and heat discomfort (15). These physical characteristics are closely related to the obese adolescent's inactivity. Lack of exercise and excess intake of fats are implicated in contributing to the later development of atherosclerosis (3).

Obese adolescents are less fit than their slender peers and are less inclined to engage in physical activity (1). In a vigorous physical education program conducted in a school system of a Boston suburb, children and their mothers sometimes mistook the effects of overheating (flushing, huffing, and puffing) for an imminent heart attack. These chldren had so seldom engaged in vigorous physical activity that the signs of exertion were unrecognizable and frightening (1).

During adolescence a growth spurt occurs which involves an increase in both height and weight, as well as a change in the relative body composition. Girls show a greater increase than boys in adipose tissue stores, as opposed to skeletal and nonadipose cell mass (3). Such changes are, of course, normal and expected; but many adolescents become anxious over both the loss of a childhood body configuration and the potential for becoming obese, which is equated with being undesirable (3).

Psychological Problems

Probably more devastating and serious than the physical problems an obese child enounters are the psychological troubles. It has been well documented that obese children have a poor self-image and express feelings of inferiority and rejection (15). These children encounter teasing and ridicule and are often left out of games, activities, and athletics and, thus, become increasingly more inactive (15).

There has been a change in our attitudes toward the obese child. In the past, obesity was considered a sign of prosperity. Parents who had fat children were obviously affluent enough to feed them (18). Today's youth consider obesity not as an admirable sign of solidarity, but a trait to be scorned and derided. Fat children suffer ridicule from their peers and become objects of embarrassment and criticism from parents, teachers, and other adults (18). According to Bruch:

> There is probably no other age group as concerned and preoccupied with their physique and appearance as adolescents--before, and even more, after pubescence. They are forever worried about their size, whether they are too tall or too short, about the adequacy of their sexual development, about their hair and skin, and their attractiveness in general; but most of all they are preoccupied with their weight (2:151).

Slenderness as a standard of beauty was extolled as the height of fashion when Twiggy (67 inches, 92 pounds) was introduced as a model for thousands of developing adolescents. Her slender appearance made them concentrate in achieving the same starved look, hence placing more pressure on those who were overweight (2). The pressures to which obese adolescents are exposed in our slimness-conscious society are reflected in the results of projective tests which showed upper class girls had heightened sensitivity to and obsessive preoccupation with the state of being fat (2). Other teenagers receiving treatment for obesity stated that they were concerned about their weight, but their real concern was appearance (18). Even clothing for teenagers is designed for the slim, svelte figure. Attempts to disguise obesity under condescending terms, such as chubby and husky do not fool children (18).

There is a confusion and disagreement about the importance of emotional factors in childhood obesity, whether they contribute to its development, or whether the psychological problems are secondary to the social rejection obese youngsters encounter (2). The attitudes of obese college students and children attending a nutrition clinic were studied, and it was observed that obese teenagers feel discriminated against but come to accept this treatment as just. They feel unable to escape their condition and become tolerant of abuse (2). Mayer (14) interprets these characteristics as passivity, similar to the resignation observed among victims of prejudice. These personality traits result from the constant pressure on the obese to become something they are not and to think poorly of themselves because of what they are (Figure 7).

While not all obese adolescents are maladjusted, or even excessively unhappy, the potential for additional problems in psychological development remains. For these young people to develop a positive self-concept and sense of mastery over the environment is particularly difficult. Obesity is not valued in this society, yet many adolescents are unable to effect lasting changes in their weight; so the task of trying to accomplish weight loss does little to facilitate an obese adolescent's sense of competence and autonomy (2).

Objectives of a Reform Program

In a discussion of a weight reform program, one should first recognize that obesity is a difficult and disappointing condition to treat and that eventual relapse is frequent (11). Statistics indicate that only about 15 percent of obese children become normal-weight adults (16). Wolfish (18) reports that the overweight teenager has an 80 percent chance of becoming a fat adult and that adults who have been fat for most of their lives have little or no success in permanent weight reduction.

Patterns

The cornerstone of weight reduction programs is to reduce energy intake below expenditure (11). Even as this equation holds true for many, it does not always apply to youth, especially the obese teenager, whose food patterns are not clearly understood (18). Many obese adolescents are actually euphagic, meaning the calorie intake is not excessive. This condition is confusing to the child, the parent, and the medical profession (18).

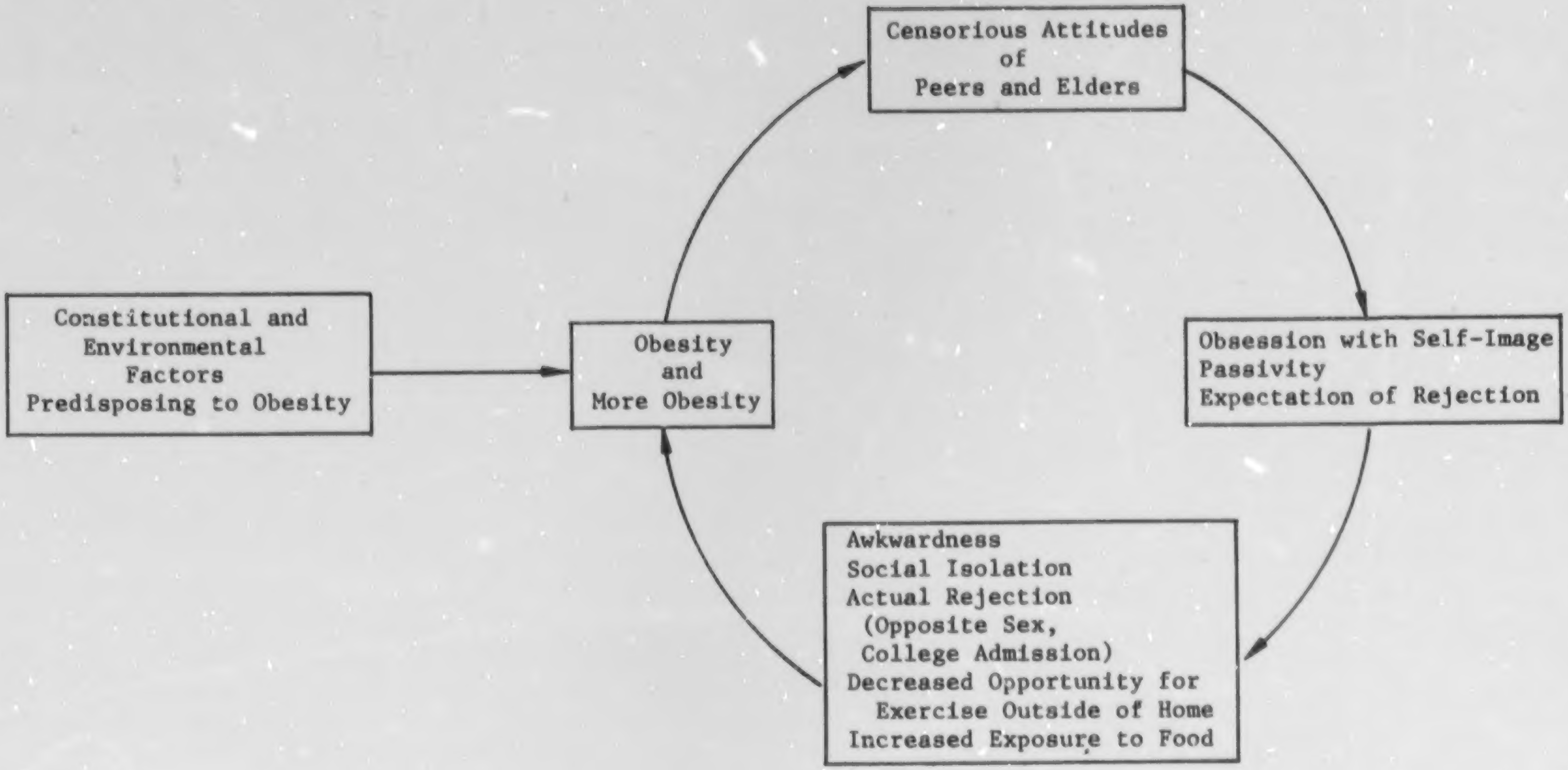

Constitutional and Environmental Factors Predisposing to Obesity
Obesity and More Obesity
Censorious Attitudes of Peers and Elders
Obsession with Self-Image
Passivity
Expectation of Rejection
Awkwardness
Social Isolation
Actual Rejection (Opposite Sex, College Admission)
Decreased Opportunity for Exercise Outside of Home
Increased Exposure to Food

Figure 7

Factors Affecting Obesity in Adolescence

Source: (14)

Wolfish (18) states that in the adolescent there are three types of obesity manifested in different types of body composition:

TYPE I - A normal amount of lean body mass is present with an increase in total body fat. This group has the most success from treatment.

TYPE II - A larger amount of lean body mass as well as total body fat is present. There usually appears to be a family history of the same composition. This group often has higher birth weights and is larger throughout life. Change is difficult during treatment, as the body tends to adhere to the fat stored.

TYPE III - No increase in total body fat or weight is apparent, but excessive amounts of adipose tissue develop in specific areas, such as thighs, buttocks, and upper arms. Individuals with this type are very difficult to treat, as decrease in caloric intake does not work (18).

Treatment

Before a specific diet or activity program begins, those treating the children should discuss with them and their parents or guardians the probable causes of obesity and the motivation to change (11). In working with obese preschool and school-age children, staff members control and modify the environment, but the youngsters still take some degree of responsibility appropriate to their maturity. The children become aware of what they eat and establish control over their food intake. This procedure requires cooperation of family, school, and relatives (15).

A weight-control program in Hawaii for sixteen obese children, six to fourteen years of age, used a team approach of individual counseling, nutrition education, and physical activity. The seven members of the "success" group (those having a weight loss of five pounds or more), by regularly keeping their appointments and faithfully keeping food and activity records, showed signs of more motivation. However, those in the "success" group generally were older, better achievers in school, became obese at later ages, and had less obese parents (13).

The formal behavior modification techniques which are applied to adults to alter eating behavior are used less with children. A pilot project of children seven to thirteen years old was carried out successfully but modified to use tangible rewards for weight loss, such as passes to bowling alleys or skating rinks to also increase physical activity. The goal was to increase adaptive behavior before maladaptive behavior became too resistant to change (15).

Bruch (2) contends that the only fat children who "outgrow" their obesity are those who, on their own initiative, make the decision to reduce. Young (19) supports this concept by referring to certain circumstances contributing to succcess in weight loss. The patient is reasonably well adjusted emotionally, has a meaningful reason to lose weight, has a realistic goal for weight loss, not a fantasy, and is in early stages of obesity.

Dietary Management

During childhood, the main goal is weight control, which allows for growth, not weight reduction. The child's bodily supply of calories and protein must allow for growth and development of lean body mass and produce a decrease in fat (15). Diets should be adjusted to individual needs; however, nutritional recommendations for children under twelve years of age are about sixty kilocalories per kilogram of ideal body weight (50th percentile value of acceptable standard), with 20 percent of calories from protein, 40 percent from carbohydrates, and 40 percent from fat. Children are not denied the basic family diet, but they eat smaller portions and avoid highly caloric foods (15).

Eating habits also have a correlation to obesity in children. Eight pairs of six- to fourteen-year-old children (one member of each pair was obese and the other nonobese) were matched on age, sex, and number of children eating together. These pairs of children were observed unobtrusively as they ate lunch in a school cafeteria. The obese children had the same pattern of eating found in obese adults, that is, a faster rate of biting, less chewing, and more extraneous responses during eating (12).

Neumann (15) made some suggestions to parents to modify eating behavior in their children by:

1. Ridding the house of "junk food" and providing low-calorie snacks
2. Furnishing appropriate-size portions
3. Avoiding the "clean-plate" syndrome
4. Cutting food into small pieces
5. Engaging the child in conversation
6. Avoiding the child's having to eat alone
7. Beginning education about food exchanges

However, the responsibility for dietary control is placed on the child with the parents as helpers (18).

Exercise

Promotion of physical activity is a part of the total reform program. Obese children are encouraged to participate in physical activities but, more importantly, to develop a habit of some regular daily exercise, such as walking, climbing stairs, or participating in regular sports (11, 15).

Although Wolfish (18) states that stressing exercise as the only means of fat reduction is a fallacious principle, Mayer is adamant that "no single factor is more frequently responsible for the development of obesity in adolescents than the lack of physical exercise" (14). He contends that weight control has been obscured by these four erroneous conceptions:

1. The overwhelming emphasis on caloric intake to the almost total exclusion of output
2. The underestimation of the caloric cost of exercise
3. The mistaken belief that increase in physical activity is always followed by an increase in appetite
4. The failure to realize that the kinds of participation, recognition, and success that adolescents enjoy, and the confidence which these bring, are mainly achieved by activities that require physical exercise (14)

Time-motion studies were completed in two girls' camps, one for the obese and the other for the nonobese. Movies taken of the girls playing volleyball and tennis, and swimming showed the obese girls had almost negligible energy expenditures. Furthermore, the overweight girls were quite unaware of their lack of participation in the activities (14).

Data from similar studies done at Camp Seascape in Brewster, Massachusetts, concurred that obese teenagers used an "economy of motion." The experiments were done with a group of obese girls who played volleyball with nonobese girls. The fat girls' team, which expended almost 50 percent less energy than the nonobese team, still managed to win the game (18).

Another program, directed by Mayer (14), in a large public school system, included several hundred obese children and adolescents. Through increased physical activity, this group lost weight and retained these losses for several years. The youths were instructed and encouraged to use proper nutrition, but they were not placed on restricted diets. Another aspect of the program included special classes which offered psychological support and daily physical education. The majority improved steadily under the regimen, particularly when treatment began at a young age (13).

Prevention

"Prevention is the only real answer to the obesity problem" (19). One should deal with the problem of childhood obesity, not during puberty, but during the early infant years (18). Also supporting this idea is the previously mentioned theory that the early juvenile state of nutrition determines the number, which remains constant, of fat cells in the body (18).

Another means of preventing obesity is to change attitudes on infant and early childhood feeding (18). Mothers should not reward young children's good behavior with high-calorie snacks. Prevention of obesity early in life is especially important because most infants who are overnourished become fat teenagers and then fat adults (18).

Inasmuch as the treatment of childhood obesity is difficult and not often effective, prevention is the better emphasis. Preventive measures attempt to control early childhood feeding and food habits acquired in later years, such as consumption of snacks, convenience foods, and foods eaten outside the home. To ensure the effectiveness of attempts at prevention, one must be certain that they balance with energy expenditures compatible with modern life (17).

Effect of Obesity on Achievement and Behavior

Studies indicate that obesity affects a child's achievement and behavior in terms of the degree to which the ridicule these children may encounter affects their self-esteem.

Achievement

The physical state of obesity itself does not affect children's potential for achievement and learning. However, external forces in the world around them often alter the inner self (2). Psychological tests prove helpful in evaluating the degree to which obese children have internalized the damaging influences of the mistreatment to which they may be exposed. As a group, obese children attained high I.Q.s on verbal tests, but were rated lower on performance tests and were significantly low in the Draw-A-Person Test (2). The latter test is indicative of a child's self-concept, thus suggesting a severe disturbance in body image (2).

A study conducted by Canning and Mayer (4) concluded that obese college applicants were rejected at a higher rate than nonobese applicants. This situation was particularly true for females. High school performances of the obese and nonobese were compared, and results (from I.Q. and SAT scores) showed that obesity and intelligence were not correlated; nor were there differences in high school academic performance, attendance records, or future plans following high school graduation. The lack of differences in obese and nonobese students led to the conclusion that prejudice against obese college applicants was greater among college admission interviewers than high school teachers.

The data gathered from observations of younger children in the weight control study done with Hawaiian youngsters showed that those who did better academically were also more successful in achieving weight loss. The success group demonstrated more motivation toward achieving their goal (13).

Behavior

Some reference to the effects of obesity on behavior is included in the discussion of problems that the obese child encounters. As mentioned before, obese adolescent girls tend to develop a passive manner in reaction to some of the prejudice they encounter. In answers given to picture-story and sentence completion tests administered by Mayer, the obese girls were "passive" and the nonobese were "active." In this context, passivity is the expression of lack of self-assertiveness and initiative (14).

Other obese adolescent girls have psychological traits similar to some other victims of prejudice. Projective tests of word associations that revealed the concerns of the subjects and their feelings were given to obese and nonobese girls attending summer camp. The obese girls gave answers which indicated a greater sensitivity to and constant preoccupation with overweight, similar to the preoccupation with status found among members of ethnic and racial minorities (14).

When obese children associate isolation and rejection with their peers, they may manifest the phenomenon of "withdrawal," the behavior that recognizes or suspects that they are unwelcome and probably deservingly so. In response to a slide of a solitary boy approaching a small group of other boys, obese girls said that the boy would remain isolated from the group. In contrast, the nonobese girls said that he would ultimately be accepted (14).

Data from a direct questionnaire given to some obese girls attending summer camps revealed that their beliefs about themselves were the same as other community members had expressed--being overweight was held in disdain. Among the responses given by the girls was that eating was a "bad habit" and associated with painful emotion (14).

Often there is a significant level of anger and discord that permeates the families of obese children and prevents parents from permitting the child's development toward independence. Sometimes the parents' overpowering and possessive attitudes interfere with the child's growing into a distinct individual whose needs and impulses are clearly differentiated from those of the parents (2). Fat children who do not "outgrow" their childhood plumpness, neither physically nor psychologically, suffer from severe deficits in the process of self-differentiation, which is associated with an inability to identify "hunger" and to distinguish it from other bodily and emotional states. Thus, they are helpless in their efforts to control food intake or to direct their lives (2).

In order to know whether dieting causes emotional depression, one would need to measure symptoms of depression and study a sufficient number of obese who are dieting and who are not. One would have to see whether there is a difference between these groups and whether increased incidence of depression becomes more frequent as caloric restriction is more severe. In the absence of such data, many of the suppositions made on the subject remain conjectural (14).

Relation to School Lunch Programs

There is little information currently available that correlates obesity with the school lunch program per se. In two English studies measuring the contributions made by school milk and meal programs given to primary school children, there was no evidence that either the additional milk or the meal was associated with obesity (7, 8). However, in adapting a preventive approach to treating obesity, federal school lunch and breakfast programs are in a particularly good position to demonstrate and teach proper nutritional practices (16).

School food service can help control obesity in children by showing that school meals are both nutritionally adequate and appetizing and that these meals offer a varied diet, which may not be present at home. Self-service canteens may even display a range of foods whose energy content is labelled as part of an educational exercise (11).

Few studies have been done on the types of food most likely to promote obesity, although there is a general impression that concentrated carbohydrate foods are particularly prone to do this (11). Unfortunately, if an adolescent is to have a nutritious diet, he or she must go to considerable trouble. Readily available foods are those dispensed from vending machines or fast food stores. These foods, which primarily contain empty calories and highly refined carbohydrates, have relatively little nutritional value. Waiting until mealtime or until one arrives home to have fruit or protein snacks means a delay in gratification, which is difficult even for many adults (3).

The student needs access to nutritious snacks both at school and home. The responsibility rests with those who are concerned with improving the nutrition of society in general. There seems little rational reason that nutritious snacks cannot be distributed in vending machines, which are readily accessible to adolescents, in particular (3).

Teachers, together with other colleagues in the school setting, play a part in diagnosis, management, and, even more importantly, in prevention of obesity in school children. Teachers are in a good position to notice obesity in its early stages and to determine whether a fat child is becoming withdrawn or is being unduly teased. Teachers who undertake supervisory duties at mealtimes can help by letting the child know they support his or her diet. Words of praise and encouragement are positive reinforcement (11).

Teachers also play a key role by their examples. Those who have their own weight under control and demonstrate appropriate eating and activity patterns provide role models for their pupils (11).

Children are captive from five to six hours per day for a period of years in the education system. Advantage can be taken of all the resources of the school in an obesity control program, including the nurse, teacher, physical education teacher, and consulting dietitian (15). Innovative school-centered obesity treatment programs have demonstrated their effectiveness (14).

Most adolescents need additional information on nutrition and health during the later years, when they can conceptualize such information in more sophisticated terms and when such information is more likely to have a personal meaning for them. The obese child who has a problem with eating and is interested in doing something about the problem may benefit from an opportunity to explore the reasons he or she fails to practice his or her knowledge about nutrition (3).

Conclusions

As noted above, the prevalence of obesity in children is of growing concern. Excessive weight can be a serious childhood physical disorder, which leads to further health complications later in life, if the condition is not corrected. Obesity places both physical and emotional stress on the child and adds to the already difficult task of growing up. Among the problems young people encounter, adolescent obesity, both in prevalence and severity, seems to be the most serious age-group problem.

Since many factors leading to the development of obesity are known, many cases could be anticipated and preventive measures invoked. After obesity develops, treatment is much more difficult because its nature seems to perpetuate itself.

Most efforts with children's weight reduction programs have demonstrated little lasting effect in dealing with obesity; adult programs produce similarly discouraging results. From the information presented, the most positive method to conquer obesity is prevention. The current efforts toward early detection and prevention of crippling or killing diseases make it also timely to similarly alter the emphasis in treatment of obesity.

Bibliography

1. Bray, G. A., ed. Obesity in Perspective: Conference Sponsored by the John Fogarty International Center for Advanced Study in the Health Sciences. Vol. 2. DHEW Publication No. (NIH) 75-708. Bethesda, Md.: National Institutes of Health, 1973.
2. Bruch, H. Eating Disorders. New York: Basic Books, Inc., 1973.
3. Caghan, S. B. "The Adolescent Process and the Problem of Nutrition," American Journal of Nursing, 75 (October 1975), 1728-1731.
4. Canning, H., and J. Mayer. "Obesity: An Influence on High School Performance," American Journal of Clinical Nutrition, 20 (April 1967), 352-354.
5. Cheek, D. B., and J. J. White. "Obesity in Adolescents: Role of Hormones and Nutrition," Proceedings of the Ninth International Congress on Nutrition, Mexico, 1972. Eds. A. Chavez, and others. Basel: S. Karger, 1975.
6. Colley, J. R. T. "Obesity in School Children," British Journal of Social Medicine, 28 (1974), 221-225.
7. Cook, J., and others. "School Meals and the Nutrition of Schoolchildren," British Journal of Preventive and Social Medicine, 29 (1975), 182-189.
8. Cook, J., and others. "The Contribution Made by School Milk to the Nutrition of Primary Schoolchildren," Journal of Nutrition, 34 (1975), 91-103.
9. Garn, S. M., and D. C. Clark. "Trends in Fatness and the Origins of Obesity," Pediatrics, 57 (April 1976), 443-456.
10. Huenemann, R. L. "Factors Associated with Teenage Obesity," Obesity. Ed. N. L. Wilson. Philadelphia: F. A. Davis Company, 1969.
11. Lloyd, J. "Obesity in Schoolchildren," Special Education: Forward Trends, 3 (December 1976), 11-13.
12. Marston, A. R., P. London, and L. M. Cooper. "A Note on the Eating Behaviours of Children Varying in Weight," Journal of Child Psychology and Psychiatry, 17 (July 1976), 221-224.
13. Matsuno, A. S., H. Hankin, and L. E. Dickinson. "Four Factors Affect Weight Control for Obese Children," Journal of Nutrition Education, 6 (July-September 1974), 104-107.
14. Mayer, J. Overweight: Causes, Cost and Control. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1968.
15. Neumann, C. G. "Obesity in Pediatric Practice: Obesity in the Preschool and School-age Child," Pediatric Clinics of North America, 24 (February 1977), 117-122.

Bibliography (Continued)

16. Stunkard, A. J. "The Obese: Background and Programs," U. S. Nutrition Policies in the Seventies. Ed. J. Mayer. San Francisco: W. H. Freeman and Company, 1973.

17. Stunkard, A., and others. "Influence of Social Class on Obesity and Thinness in Children," Journal of the American Medical Association, 221 (August 7, 1972), 579-584.

18. Wolfish, M. C. "Nutritional Prolems in the Teenager, " Journal of the Canadian Dietetic Association, 36 (1975), 20-26.

19. Young, C. "Overnutrition," World Review of Nutrition and Dietetics, Vol. 16. Ed. M. Rechcigl. Basel, Switzerland: Karger-Basel, 1973.

CHAPTER 7

Malnutrition and Dental Problems

Research studies reveal that nutritional habits influence the development of dental caries and periodontal disease. Certain kinds of foods destroy tooth enamel and gum tissue; others prevent decay.

Prevalence in Children

Dental decay is among the most prevalent of all human diseases affecting inhabitants in every part of the world. In general, the more affluent the population group, the more prevalent the disease (3).

Within the United States, a relatively affluent nation, the Ten-State Nutrition Survey showed that, among children from different subgroups of the population, there was a considerable variation in the number of decayed and filled teeth. The number of dental caries in the permanent teeth of children generally increased with a child's age (10). However, the data on decayed, missing, and filled (DMF) teeth showed that the older Spanish-American children had the lowest level of dental care. There was a relationship between the prevalence of caries in adolescents and the intake of foods containing sugar. In addition, the data generally indicate that, in many segments of the population surveyed, inadequate care of the teeth causes poor dental health (10).

Both dental caries and periodontal disease are major oral health problems. Dental caries are more prevalent in youth, and periodontal disease occurs in later years. Present concepts favor the view that diet and nutrition, as well as oral hygiene and dental care, play an important role in prevention and control of both these diseases (8).

A recent survey in England of 3,000 school children showed that by the time most of the subjects reached age thirteen, caries had attacked an average of ten teeth per child. Only 40 percent of these teeth had been treated by dentists; the rest received no treatment. On the average, the children's consumption of sweets was 17.5 ounces per week; some children, however, ate more than three pounds of sweets each week (4).

The Ten-State Nutrition Survey showed that an unusually high prevalence of periodontal disease was reported. In persons less than eighteen years of age, periodontal disease consisted predominantly of gingivitis (disease without pockets (10). Other studies show that periodontal disease ranges from 10 percent in five- to nine-year olds to 50 percent and over in persons seventeen years of age or older (8).

Correlation Between Dental Disease and Nutrition

Results from studies on the relationship between dietary habits and dental disease reveal that eating habits influence the health of one's tooth enamel and gum tissue.

Caries Formation

"Dental caries is basically a local disease of the teeth subject to the influence of those dietary components which provide food and sustenance for the plaque bacteria" (3). Decay develops after part or all of the tooth has emerged into the oral cavity and has been exposed to the action of the oral microflora. The organisms collect on the surface of the exposed tooth at sites protected from the cleansing action of mastication and form plaque. Then the caries lesion starts beneath the plaque and progresses inward toward the pulp, destroying the enamel and dentin (3). The rotting process is called caries because it refers to the Latin word carius, meaning rotten (6).

The surface layer of enamel, the first of the tissues usually attacked by caries, is more heavily mineralized and more resistant to the carious process than are the deeper layers. This layer contains higher concentrations in fluoride, zinc, lead, maganese, tin, and iron and lesser amounts of carbonate, sodium, and magnesium than the underlying enamel. An increased level of enamel carbonate is correlated with caries susceptibility, and an increased enamel fluoride with caries resistance (3).

Newly erupted teeth are considerably more susceptible to decay than older teeth. Enamel is believed to undergo a process of maturation following tooth eruption and exposure to the influence of saliva, which increases its resistance to cariogenic agents (3).

The importance of saliva as a protection against dental caries is clearly demonstrated by the striking increase in the incidence of caries following the removal of major salivary glands in animal studies or the onset of xerostomia in man. There is also a tendency for saliva-flow rates to be higher in caries-immune rather than caries-active persons. The buffering capacity of human saliva is highly individualistic, but studies have shown that stimulated saliva has a higher buffering capacity than resting saliva and is more effective in the neutralization of mouth acids and plaque (3).

Periodontal Disease

There is less research and therefore less is known about the relation of diet to periodontal disease than is the case with dental caries. However, it is known that nutrition can condition the periodontal tissues either to resist or succumb to disease (8).

Many factors influence the onset of periodontal disease. Systemic factors have a greater effect on the periodontal tissues than on the surfaces of the teeth. Local irritants, such as dental plaque, dental calculus, food impaction, and mechanical, chemical, and thermal extremes can cause disease (6). The major nutrients that contribute to the condition of the periodontal tissues are protein, ascorbic acid, B-complex vitamins, vitamin A, calcium, phosphorous, and vitamin D (6).

Studies on the epidemiology of periodontal disease indicate the incidence may be related to both a calcium deficiency and an imbalance of the calcium and phosphorous ratio of the diet (8). Statistics indicate that in the United States a relative imbalance exists since the phosphorous content of the average diet is 2.8 times greater than the calcium content (8). This same trend appears in other societies which consume large quantities of meats and other foods containing phosphorous (6).

Nutritional Factors

A number of nutritional factors, such as eating habits and refined carbohydrates influence dental health.

Eating Habits

Results from modern studies on humans have raised questions regarding the importance of nutritional and dietary factors in dental health. For example, while vitamin A is believed to be essential to tooth and bone development which occurs during the first eight years of life, very few cases of abnormalities resulting from vitamin A deficiencies are identified in the United States. On the other hand, both dental caries and periodontal disease are related to the intake of refined carbohydrates and the amount which remains on the teeth. Hence diet, rather than nutriture, has a major influence on caries and periodontal disease (10).

A survey of the relationship between caries prevalence and the human consumption of sugar and other foods high in sugar content shows that snack foods share importance with sucrose as causes of caries, which occur not only because of the carbohydrate composition of these foods, but because they are frequently eaten between meals (1), thereby increasing one's sugar consumption.

Another study of the comparison of the general and dental health and the food habits of randomly selected four-year-old Swedish urban children was performed. The results were compared with the findings of an investigation carried out four years earlier in the same area. Results showed that a change in food habits caused a reduction in the frequency of the consumption of sweets and soft drinks between meals. A reduced intake of meat, fish, and eggs and an increase in sandwich and milk consumption occurred. The decrease in the amount of foods consumed between meals and the increase in the number of fluoride tablets children took may explain the reduced frequency of caries among the children studied (9).

The Ten-State Nutrition Survey (10) found that the most important change that made a diet less cariogenic was to reduce the frequency of sweet-foods consumption. Studies of rats revealed that doubling the number of feeding periods from four to eight caused a major increase in caries. When the number of meals was increased to thirty-five per day, the number of caries in the rats increased tenfold (10).

Role of Carbohydrates

The first recorded suggestion that consumption of sweet foods might be a cause of dental decay was made by Aristotle 2,000 years ago when he wondered why soft, sweet figs damaged the teeth. Since that time, with the evolution of more refined, synthetic diets, the incidence of dental caries has progressively increased (6).

Carbohydrates have basically the same nutritional role, but their dental effects vary. The most common carbohydrate in the diet is sucrose, followed by starch and then glucose (4). Studies have been done with animals to test the effects of carbohydrates on dental decay (4). Sucrose caused by far the most caries; glucose caused much fewer; and starch was almost noncariogenic. All types of breads and cereals were harmless unless sugar was added (4).

The relationship between the long-term consumption of refined carbohydrates (foods with high quantities of sugar, such as pastries, candies, soft drinks) and DMF teeth has been established beyond a reasonable doubt, and the consumption of refined carbohydrates between meals is usually associated with higher DMF scores than consumption of similar foods during meals (10).

In the United States, carbohydrates contribute 50 to 60 percent of the total daily caloric intake. Fermentable carbohydrates comprise 25 to 50 percent of the carbohydrate component (3). The cariogenicity of the fermentable carbohydrates varies with the physical form, chemical composition, and presence of other food constituents. For example, sticky, solid carbohydrates are more cariogenic than those consumed as liquids. Carbohydrates in detergent foods, those which are firm and create a scrubbing action when chewed, are less damaging than those in soft, retentive foods. Polysaccharides are less readily fermented by plaque bacteria than monosaccharides. And meals high in fat, protein, or salt reduce the ability of carbohydrates to remain on the teeth (3). Figure 8 shows the role of dietary carbohydrates in oral disease.

Among the fermentable carbohydrates, sucrose is consistently implicated as the most cariogenic. Certain properties, such as its solubility, diffusibility, and molecular weight, are responsible for the caries-promoting effect. Sucrose also releases more energy during hydrolysis than the monosaccharides or other disaccharides; therefore this sugar form enters into chemical reactions more readily (10).

After the teeth have erupted, the most significant dietary influence on the formation of caries is the frequent ingestion of carbohydrates capable of penetrating dental plaque and stimulating acid-producing organisms. Measurements show that, following each meal, acid containing fermentable carbohydrates, accumulates within the plaque. The acid continues to act for 30 to 45 minutes after ingestion (3).

Another study was conducted to determine the speed and duration of acid production in dental plaque after sucrose touches the surface. Results showed that it took 20 to 30 seconds for acid strong enough to cause tooth decalcification to appear, and this condition lasted for 30 minutes. Thus, consumption of sweets every 30 minutes will cause one's teeth to be immersed in a continuous, destructive acid environment (6).

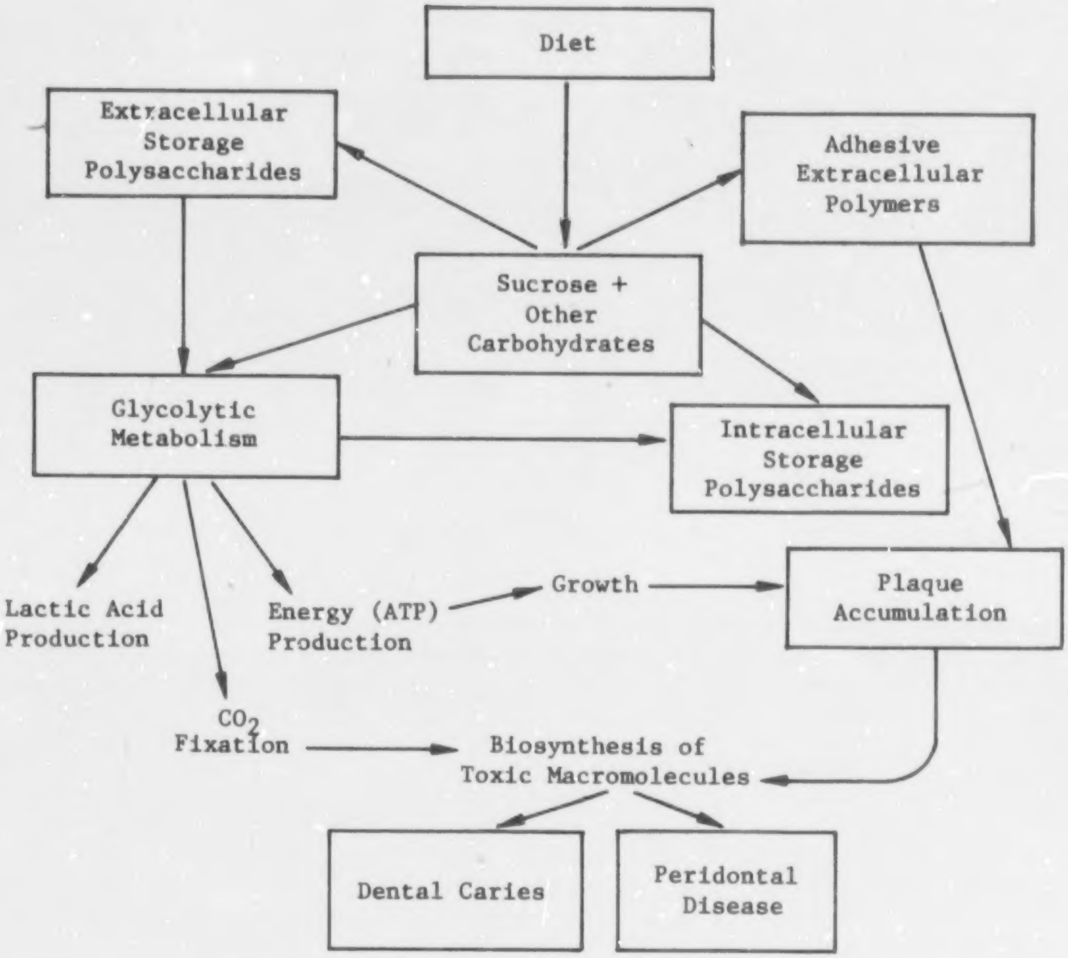

Diet
Extracellular Storage Polysaccharides
Adhesive Extracellular Polymers
Sucrose + Other Carbohydrates
Glycolytic Metabolism
Intracellular Storage Polysaccharides
Lactic Acid Production
Energy (ATP) Production
Growth
Plaque Accumulation
CO2 Fixation
Biosynthesis of Toxic Macromolecules
Dental Caries
Peridontal Disease

Figure 8

The Role of Dietary Carbohydrates in Oral Disease

Source: (2)

A report from England by a panel on cariogenic foods revealed that frequent sucrose feedings to infants produce caries. The panel also correlated the addition of sucrose with vitamin mixtures and fruit juices to the increase in caries (10).

Experiments on human consumption of breakfast cereals, contrasting those with and without sugar, supported the same conclusion. The sugar-coated cereal produced almost four times as many caries as an unsweetened whole-wheat cereal (4).

Both crude or natural sugar, as well as the refined type, can cause dental caries. Experiments using coarse brown sugar, coarse granulated refined sugar, and powdered glucose have proven the degree of refinement was not critical, but the sticky consistency of the powdered sugar was cause for more caries (6).

Dental patients who have a hereditary fructose intolerance do not utilize simple sugars and appear to be almost caries-free because they can tolerate only starches, such as wheat, rice, and potatoes as a source of carbohydrates.

In another study, Guatemalan children who ate candy, cake, and other sweets harbored more cariogenic bacteria in their dental plaque than those who ate a high-starch diet (6).

Chocolate is less cariogenic than most people think although it has a high sugar content and some cariostatic factors have been found in cocoa powder. Only minimal research has been reported, but one observation indicated that a group of students who consumed a high-chocolate diet for five days developed less plaque in their teeth than after they consumed a normal diet during a similar time period (4).

Present knowledge indicates the only other food chemical besides sucrose that has a significant cariogenic activity is the trace element selenium. This conclusion is based on dental studies in the northwestern section of the United States, where selenium is relatively high in the foods (6). In studies of animals, the incidence of caries was increased when selenium was ingested. This speculation is that the incorporation of selenium during tooth formation changed the protein components of the enamel and made this substance more prone to caries attack (6).

Prevention

Several existing means may prevent tooth decay and gum disease: the use of fluoride, certain combinations of chemicals on foods, and diet counseling. The following paragraphs describe these methods.

Fluoride

As with most other diseases, prevention of oral disease is preferable to treatment after the damage has occurred. Fluoride is the only dietary element which has been proven significantly effective in producing decay-resistant teeth. The incidence of dental caries in both deciduous and permanent teeth is reduced to about 60 percent in children who, throughout the period of tooth development, drink water containing 1.0 ppm of fluorine (3). There are indications that the caries inhibition demonstrated is not merely temporary but continues throughout adult life. In contrast because there are only trace amounts of fluoride found in foods, it offers little protection against dental decay (3).

Grenby (4) agrees that the water supply is the best means for widespread distribution of fluoride, but he states that certain foods have also been tested as vehicles. In Switzerland, table salt, which contains 200 ppm sodium fluoride, and is on the market, has reduced caries in children. Some Scandinavian researchers have advocated putting sodium fluoride in bread and cereal products at a level of 3.5 mg. fluoride per kg. In various parts of Europe and the United States researchers have found that milk containing 2.0 mg. fluoride per pint is an effective means to reduce caries (4).

Because of the adverse physical effects of overconsumption, the amount of fluoride ingested must be controlled. However, when only 1.0 ppm fluoride is ingested daily, there are two significant systemic factors against toxicity; namely, the rapid elimination of fluoride by the kidneys and the affinity of calcified structures for fluorides (6).

Presently, the inability of supplemental fluorides to protect all teeth from decay indicates an incomplete knowledge of the components that make the tooth structure resistant to caries (3). Further research into fluoride and other elements is needed.

Other Treatments

There may be no single element, such as fluoride that will reduce the number of dental caries, but a search for a mixture of elements in a certain ratio to each other is warranted (6). There are other food combinations, some still speculative, that affect caries formation. In studies of animals, the manipulation of the vitamin, mineral, and trace-element content of the diet during tooth formation modified the chemical composition of their teeth. Rats fed a high-calcium, low-phosphate diet form caries-susceptible teeth. Those given a low-calcium, high-phosphate diet are less vulnerable to caries. However, such diets are otherwise physiologically detrimental (3).

Other evidence supports the value of phosphate supplements. A study conducted on the cariostatic effect of calcium sucrose phosphate added to carbohydrate foods in a group of children, aged five to seventeen years, showed a significant overall beneficial effect up to the thirteen year olds. A reduction in caries continued in the thirteen- to seventeen-year-old group, but this decline was less remarkable. The overall reduction was about 25 percent in total caries increment (5).

In a second study, phosphate was added to a number of different breakfast cereals, which were provided to the subjects in sufficient quantities. After a year, a 40 percent reduction of caries occurred (5). And in a third study to test the effect of sodium dihydrogen phosphate added to breakfast cereal, the results were the same. In the controlled setting of an institution, persons less than twenty years old revealed a 40 percent reduction in the incidence of dental caries (5).

However, there are results from still another test during which 1 percent sodium dihydrogen phosphate was added to enriched pre-sweetened cereals, which were given to children. At the end of two years, results showed that the new caries increment was actually higher in the test group than in the control group (5).

Still other investigators feel that the presence of more than usual amounts of calcium and phosphate ions serves to buffer acid production in dental plaque (10). Results of experiments concluded that the calcium and phosphate in milk had as much protective effect against caries formation as did the protein present (10). Further experiments in decalcification of enamel tested hard, red winter wheat against spring wheats. The spring wheats decalcified the least, a phenomemon attributed to the higher protein content (10). Protein supplementation has also been found to produce significant improvement in gingival health (10).

Grenby (4) feels that, if the public is not interested in voluntary measures to reduce the incidence of dental caries, food manufacturers might modify their products to make them less cariogenic. This process could involve replacing sucrose with other sweeteners, either nutritive or nonnutritive. Nonnutritive sweeteners, such as saccharin, have no cariogenic properties; and they could play a useful part in dental health (4).

In experiments on animals, a number of antiseptics were used to control caries by suppressing oral microorganisms. The majority of these germicides were found to be suitable only for mouthwashes or toothpastes, not for dietary additives (4).

Some trace elements and vitamins may inhibit the development of caries. Research has indicated that the trace elements, molybdenum and vanadium, may have a beneficial effect on reducing the incidence of dental caries (8). A. E. Nizel found that vitamin B6 (pyridoxine) supplements in the form of troches have a caries-inhibiting effect. The mechanism of action of this vitamin may be its ability to alter the oral flora from a cariogenic to a noncariogenic type (6).

Diet Counseling

To prevent dental disease, one should have a diet that is adequate, balanced, and varied. To cure chronic periodontal diease, one should eat foods that have a firm consistency and require chewing to stimulate the gum tissue and that have a detergent effect so that dental plaque and calculus will not readily form (8). Nizel (7) recommends that dietary guidance should be considered part of a total oral physiotherapy program and therefore should be taught with the same diligence as tooth brushing and interdental massage. Data in Table 11 show some procedures to be included in counseling sessions.

Nizel (7) suggested an approach that provides individualized nutritional guidance to the caries-susceptible adolescent. First, the subject completes a five-day food diary showing foods eaten and food habits. Next, the subject is counseled to understand the reasons for selecting nutritious food. Finally, an acceptable diet is prescribed. This diet should be nutritionally adequate and should eliminate as much as possible between-meal eating of retentive sweets and other cariogenic foods.

Table 11

Procedures Necessary to Prevent and Control Dental Caries

Tooth	1. Improve quality and structure
	2. Increase resistance of enamel surface
Bacteria	3. Decrease dental plaque formation
	4. Interfere with bacterial enzyme activity
	5. Remove dental plaque mechanically
Saliva	6. Stimulate flow rate
	7. Increase ability to neutralize acid
	8. Increase remineralization capacity
Food	9. Decrease sucrose intake
	10. Decrease frequency of eating
	11. Increase oral clearance
	a. Less sticky
	b. More firm and detersive
	12. Improve food quality and food practices

Source: (6)

Dietary counseling is used at the Manchester University Dental School in England. The dentist or dental student obtains from a child's mother a record of his or her food intake. A standardized technique is followed to analyze the diet for nutritional adequacy, amount of sugar, and the timing and distribution of intakes of sugar-containing and fibrous foods. The diet analysis then forms the basis for dietary counseling (8).

Conclusions

Since ancient times, the relationship between causes of dental caries and dietary factors has been suggested. Investigations through the years, especially on the effects of fluoride in drinking water, of sugar and other carbohydrates in various forms, and of their frequency of intake, have revealed important information on dental health. The influences of genetic factors, race, climate, and tooth structure have proven to be of relatively little importance in the process of dental caries formation (7).

Nutrition and dietary factors play a major role in caries formation. Some dietary components have proven favorable in the successive developmental stages of the teeth; other components proved detrimental. Therefore, appropriate dietary measures and dental hygiene should improve oral health and reduce the incidence of caries.

Bibliography

1. Bibby, B. G. "The Cariogenicity of Snack Foods and Confection," Journal of the American Dental Association, 40 (January 1975), 121.

2. Brown, A. T. "The Role of Dietary Carbohydrates in Plaque Formation and Oral Disease," Present Knowledge in Nutrition. Ed. D. M. Hegsted. Washington, D.C.: The Nutrition Foundation, Inc., 1976.

3. Drezen, S. "Diet and Dental Decay," Postgraduate Medicine, 43 (March 1968), 233-236.

4. Grenby, T. H. "Research on the Control of Dental Decay and Plaque Formation by Alterations to the Diet," Royal Social Health Journal, 95 (1975), 139-141.

5. Mandel, I. D. "Dietary Modifications on Caries in Humans," Journal of Dental Research, Supplement No. 6 (November 1970), 1201-1211.

6. Nizel, A. E. "Nutrition and Oral Problems," World Review of Nutrition and Dietetics, Vol. 16. Ed. M. Rechcigl. Basel, Switzerland: S. Karger, 1973.

7. Nizel, A. E. Nutrition in Preventive Dentistry: Science and Practice. Philadelphia: W. B. Saunders Co., 1972.

8. "Nutrition in Oral Health: Research and Practice," Dairy Council Digest, 40 (November-December 1969), 31-34.

9. Samuelson, G., and others. "An Epidemiological Study of Child Health and Nutrition in a Northern Swedish County," Acta Pediatr. Scand., 94 (1975), 241-247.

10. U. S. Center for Disease Control, Atlanta. Ten-State Nutrition Survey 1968-1970. Department of Health, Education, and Welfare Publication No. (HSM) 72-8131.

CHAPTER 8

Hyperactivity

The frequent and widespread usage of the term hyperactivity among those who deal with children often leaves the impression that this syndrome is commonly understood. In reality, the prejudices and stereotypes about hyperactive children often surpass the factual understanding of this group (1).

The terms hyperactivity, hyperkinesis, hyperkinetic syndrome, and minimal brain dysfunction (MBD) are often used interchangeably. There is presently little agreement on whether they represent the same syndrome or whether they are several syndromes which overlap (9).

There have always been hyperactive children, but the written history of the disorder is relatively short. The work of Werner and Strauss (1) in 1941 represented a landmark in the understanding of the hyperactive child. Their research indicated that the types of errors hyperactive children made in learning differed from those exhibited by the mentally retarded children, with whom they were previously classified (1). Knowledge about hyperactivity, which has increased over the years, reveals that the syndrome should be viewed as a combination of behavioral, cognitive, emotional, and physiological dysfunctions (1).

According to Alabiso and Hansen (1), hyperactive children are well-known to every elementary school teacher, since one out of every ten elementary school students is hyperactive (1). The typical child is likely to be about seven years old when the overactivity first becomes apparent. The condition was probably not diagnosed during the preschool period and will appear only in less noticeable secondary stages when the child reaches high school age. Boys are five times more likely to be hyperactive than their female classmates (1).

Smith (22) identified several common traits in children being treated for hyperactive behavior. His patients were mostly fair-haired, had light-colored eyes, were very ticklish, had sleep disorders, demonstrated definite "mood swings," and had unstable blood-sugar levels, probably resulting from excessive intakes of carbohydrates.

Etiology

Understanding the causes of hyperactivity is an awesome task. Although the syndrome was identified over 100 years ago, only within the last two decades have some of its causes been uncovered (1). There are three principal causes associated with hyperactivity: brain-stem dysfunction, frontal brain damage, and psychogenic causes.

Brain-Stem Dysfunction

The most prominent theory is that hyperactivity is primarily a physiological condition which is caused by a disturbance of the functioning of the brain stem (1). Within this area, the subcortical center relays incoming impulses to the brain and transmits impulses from the brain back to the sense organs. Within the reticular formation (brain stem) lie the thalamus and hypothalamus, which serve as terminals for incoming and outgoing nerve impulses. This area of the human nervous system is responsible for human arousal (1). Certain drugs inhibit impulse transmission, thus decreasing the activity level.

Although an injury or infection could cause the hyperactivity that results from a malfunction of synaptic transmission within the brain stem, research suggests that a developmental lag is responsible for the majority of cases (1). The developmental lag theory, which attributes the brain-stem dysfunction to uneven physiological development, places an emphasis on the process of maturation. The theory hypothesizes that the brain (cerebral cortex) develops at a normal rate whereas the brain stem (reticular formation) matures at a slower rate (1).

Frontal Brain Damage

Brain damage is another suspected cause of hyperactivity, although the role of the cerebral cortex in causation is not as clearly defined as is that of the brain stem (1). Some studies cited by Alabiso and Hansen on the subject suggest that hyperactivity was directly related to a disturbance in one's ability to inhibit and control temporal lobe activity. One study indicated that temporal lobe lesions were present in some hyperactive children, and another suggested that a malfunction of the prefrontal lobes of the brain was associated with hyperactivity (1).

Psychogenic Causes

The third suggested cause of hyperactivity is psychogenic influence. For some children whose hyperactivity is not organically based, this syndrome may be an emotional response to a maladjusted home life or a reaction against underlying feelings of depression. The theory suggests that, by becoming overactive, the hyperactive child defends himself against lethargy and other feelings of depression (1).

Cantwell (3) revealed a relationship between hyperactivity in children and a disturbance in the parent-child relationship. He studied fifty hyperactive children and found a high prevalence of parents who suffered from alcoholism, personality disorders, or hysteria.

Morrison and Stewart (15) and Cantwell (3) conducted studies to determine the genetic etiology of hyperactivity among children. From their studies of adopted hyperactive children, they concluded that there is genetic transmission of the hyperactive-child syndrome. Morrison and Stewart (15) found a significant incidence of childhood hyperactivity in the parents of children included in their study.

Other causes of hyperactivity may be: low-level lead poisoning, carbon monoxide poisoning, oxygen deprivation at birth, fluorescent lighting, and food additives. No conclusive studies have established the foregoing as causes of hyperactivity (9).

Effect on Behavior and Achievement

Certain basic symptoms which identify hyperactive children are presented below:

1. These children exhibit a disturbance of activity level and usually demonstrate difficulty in reducing their rate of activity.

2. These children suffer from disorders of attention that include short attention spans, difficulty in focusing their attentions, and a high rate of distractability.

3. Hyperactive children also experience cognitive dysfunctions: Their pattern of intellectual abilities is characterized by unevenness and disparity between various abilities. These children may experience difficulties with visual and auditory memory, and their ability to produce an acceptable answer may be impaired by deficits in verbal and motor expression.

4. Many hyperactive children appeared to be unduly impulsive. They responded quickly during problem-solving tasks and seemed to lack the problem-solving strategies most children use to evaluate their response alternatives (1).

Secondary characteristics in hyperactive children include aggressiveness, poor concentration, emotional instability, and failure in social relationships. These children suffer from a general impairment which prevents their academic progress, and they exhibit changes of mood and a low tolerance for frustration. Hyperactive children often find themselves socially isolated and ostracized by their peer groups; so they sometimes have a poor self-image and damaged self-concept (1).

Miller (13) contends that the hyperactive children treated in his medical practice have problems with excessive internal anger, often self-directed, but intermittently directed outward. This agitation is manifested in hyperkinetic activity.

A significant relationship between hyperactivity and depression was indicated from the results of fifty-seven hyperactive chiildren rated on the Kissel-Freeling Depression Scale (1). Those children who received high hyperactivity scores were also described by their teachers as sad and lonely, easily provoked to tears, lethargic, and subject to self-pity.

In the classroom, hyperactive children present a serious management problem to teachers (14). Minde and others (14) described these children as exhibiting many behavior problems that distracted other children in the classroom. The hyperactive children also maintained a high rate of academic failure although their level of intelligence was usually average.

Gofman (7) has identified hyperactive children as suffering from a multiplicity of learning deficits. Disorders of language development, as well as auditory discrimination and sequencing abilities, are characteristics of the hyperactive child's learning difficulties. These children suffer not only from visual-motor and visual-memory deficits, along with gross motor incoordination, but they also have an inability to recognize tactile stimuli and to correctly formulate right-left discriminations (7).

Several studies have attempted to show the effects of hyperactivity upon intellectual performance. In a study of academic performance Minde and others (14) conducted with thirty-seven hyperactive school children, results showed the children had a significantly higher failure rate than their nonhyperactive classmates. Palkes and Stewart (18) studied the relationship between intelligence, school achievement, and perceptual motor development in hyperactive elementary school children. They found that although the children demonstrated lower I.Q. scores than those of a control group, the hyperactive children learned at a rate that was normal for their level of intelligence. However, Alabiso and Hansen (1) noted that there has been much controversy over the relationship between hyperactivity and intelligence, but no cause-effect relationship between hyperactivity and lowered intelligence has been shown.

While the primary characteristics of hyperactivity diminish with age, the residual effects of the handicap can be devastating. Of the particular children identified by Alabiso and Hansen (1), a significantly high incidence of social and intrapsychic difficulties accompanied by severe learning disorders were found to persist into the adolescent period. By the time these youths had reached adolescence, they saw themselves as lonely and isolated. Although the primary characteristics of the syndrome were generally diminished, the hyperactive adolescents were not able to deal with the complex tasks of identifying and preparing for a career choice.

Mendelson and others (12) interviewed the parents of adolescents who, while in elementary school, were diagnosed as hyperactive. These investigators concluded that although, by adolescence, the children generally behaved in a more normal manner, the primary symptoms of high activity level, distractibility, impulsiveness, and excitability remained to a lesser degree. The primary maladaptive behaviors were those of disobedience, rebelliousness, antisocial behavior, and apathy. Academic failure and low self-esteem were typical school attitudes.

Treatment

Three main treatment approaches for the hyperactive child are: chemotherapy (drugs), behavior intervention, and dietary modifications. While these methods have developed along separate lines, the most effective approach might be a combination of the three (1).

Drug Therapy

Drug therapy has received the greatest emphasis for treatment of hyperactive children. Two main classifications of drugs used to treat hyperactivity are: psychostimulants and phenothiazines, or tranquilizers.

Psychostimulant drugs (amphetamines) have their effects mainly on the brain stem and are most useful in the treatment of hyperactive conditions arising from unevenness in physiological development (1). Psychostimulants are used most commonly in drug treatment because they reduce hyperactivity by permitting impulses to travel more freely between the nerves and brain stem. While a variety of psychostimulants has been tested, methylphenidate (Ritalin) is generally chosen as the most effective in controlling hyperactivity (1).

In a comparison study, Sprague and others (23) measured the effects of placebos, tranquilizers, and psychostimulants on a group of hyperactive boys. The psychostimulant group showed the greatest reduction in activity level and improvement in learning ability and in reaction time. Weiss and others (24) also compared the effectiveness of psychostimulants with tranquilizing drugs. The psychostimulants were, again, found to be superior in controlling hyperactivity. The tranquilizers were effective for a majority of the children, but they acted to reduce only the activity level and were not effective in reducing distractibility, aggressiveness, or excitability.

While it is not possible to conclude on the basis of a few studies that drug treatment affects intelligence, findings do suggest that drugs may positively affect the general cognitive process (1). Campbell and others (2) support such a theory. In the comparison study of hyperactive children after psychostimulant drugs were administered, a significant improvement was noticed in areas of cognitive style.

The use of methylphenidate and Dexedrine (both psychostimulants) affects the growth pattern of children. In a study of hyperactive school-age children, Safer and others (20) reported these drugs caused a suppression of weight gain and a depression of growth and height. The differences in height and weight were noticeable within nine months. However, growth reappeared spontaneously when the medication was discontinued.

Studies by Lucas and Sells (11) also confirm an adverse effect on growth caused by the use of stimulant drugs. Since 300,000 children, or 2 percent of all elementary school children in the United States, are receiving stimulant medication, a significant number of them may risk the suppression of their optimal physical growth (11, 17).

Tranquilizing drugs produce beneficial effects in those children whose hyperactivity is not caused by a malfunction of the brain stem. This category of drugs, known as phenothiazines, acts to inhibit processing of nervous impulses and often results in improvement in psychogenic hyperactivity (1). Data from the study by Weiss and others (24) indicate that chlorpromazine (a major tranquilizer) was quite effective in reducing activity levels of hyperactive children but resulted in little effect on distractibility, aggressiveness, or excitability.

The major limitations of tranquilizer treatment of hyperactive children are their narrow range of effectiveness and their potential side effects. Reported side effects include an increase in irritability, loss of sleep, loss of appetite, and psychomotor retardation (1).

In an effort to find an alternative to the use of stimulant drugs in treatment of hyperactivity, a double-blind experiment* was conducted to determine the effects of caffeine on hyperactive children. Results from the study indicated that caffeine produced an increase in the accuracy of stimulus identification and a decrease in lapses of attention (19).

Drug therapy cannot change the patterned activity of a child. If a child has a social interaction problem that is possibly secondary to his or her hyperactivity, drugs could change the excitability that caused the aggressive actions. Drugs, however, cannot be a substitute for helping to improve the child's feelings (6).

Behavior Modification

Behavior modification techniques offer another form of treatment for the hyperactive child. This approach does not deal with the internal causes of a child's actions, but instead emphasizes the environmental stimuli which elicit and reinforce hyperactive behavior. The hyperactive child differs from other children only in the frequency with which he or she exhibits certain behavior (1).

Behavior modification with hyperactive children relies heavily on the use of environmental control and reinforcement techniques to shape and diminish the child's excess behavior. A study by Alabiso and Hansen (1) showed that a number of high-frequency behaviors associated with the hyperactivity syndrome could be brought under control through the systematic use of positive reinforcement.

Behavioral techniques are used in the classroom to control hyperactive children. Because their peers often socially ostracize these children, they are maintained in the regular classroom in an attempt to reverse this rejection process. Another technique to modify the behavior of these children is through the provision of special learning modules that offer remedial instruction in specific areas of learning disabilities (1).

O'Leary and Pelham (17) expressed concern with the effects associated with the use of drug therapy. They stated that drug treatment:

1. Appears to have no long-term effect on academic achievement

2. Does not appear to decrease long-term social problems

3. Increases heart rate and blood pressure

4. Decreases the rate of height and weight gains

5. Affects the child's attitude about taking drugs to alter his or her behavior

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*A double-blind experiment is a study of the effect of a specific agent in which neither the administrator nor the recipient, at the time of administration, knows whether the activity, or an inert substance is given.

Results of studies by these researchers suggest that behavior therapy is an effective and viable alternative intervention for some children who receive stimulant medication for hyperactivity. However, the behavioral treatment was more effective for changing social behavior than for improving attention skills (13).

Feingold Theory

Recent claims have indicated certain chemicals found in foods, some present naturally and others added in processing, may be responsible for the hyperactive syndrome in children (16). The most emphatic and well-recognized claims come from Benjamin F. Feingold, M.D., emeritus director of the Laboratory of Medical Entomology of the Kaiser Foundation Research Institute (5). He has attributed the behavioral disturbances of hyperactivity and learning disabilities to salicylate-like natural compounds in foods, to low-molecular weight food additives, and to artificial food flavors and colors.

As therapy for hyperactivity, Dr. Feingold (5) has prescribed a diet which eliminates a wide variety of natural and processed foods. He claims dramatic improvements in patients so treated, and he has appealed to the Food and Drug Administration for complete label declaration of ingredients and the use of a special symbol on products to indicate the absence of synthetic colors or flavors (9).

The Feingold hypothesis contends that hyperactivity is associated primarily with the ingestion of low-molecular weight chemicals. He includes in this category salicylates, compounds which react with salicylates in the body, and common food additives (5). The treatment he suggests is dietary and is based on an "exclusive diet" or the "K-P diet." Feingold reports that twenty-one fruits and vegetables (5) contain natural salicylates and must be omitted. In addition, he prohibits all foods which contain artificial flavors and colors; fifty-four foods appear in his book as examples.

Smith (22) agrees with Dr. Feingold's diet prescription for hyperactive children but suggests further limitations. Smith states that, in addition to restricting food additives, certain foods should be eliminated from the diet because of their harmful effects and their influence on blood-sugar levels. He suggests elimination of sugars, syrup, honey, ice cream, breakfast cereals, white flour, and pasteurized milk from the diet. He also recommends that nutritious snacks be offered in the classroom enabling children to nibble, thus preventing a decline in blood sugar. In addition to diet change the children being treated by Dr. Smith were given increased doses of vitamin C, B-complex vitamins, calcium, and magnesium. Improvement was noted within three weeks.

Although Dr. Feingold claims success in relieving symptoms in hyperactive children with the K-P diet, he has been criticized for a lack of results in controlled studies. The National Advisory Committee on Hyperkinesis and Food Additives (16) concluded that no controlled studies have demonstrated a relationship between hyperkinesis and the ingestion of food additives. The committee further states that there is no confirmation that children improve significantly on a diet free of salicylates and food additives and that the Feingold diet may not meet the long-term nutrient needs of children.

Data from a double-blind study designed to test the Feingold diet under controlled conditions revealed no significant overall effect of the diet on children's behavior as measured by teachers and parents (8). However, a double-blind trial by Conners and others (4) involving a control diet and one that eliminated artificial flavors, colors, and natural salicylates, as recommended by Feingold, was conducted on fifteen hyperkinetic children. The conclusion was that the K-P diet may reduce hyperkinetic symptoms, although the diet may be less than nutritionally adequate.

Without conclusive evidence from reliable studies, the effectiveness of the Feingold diet remains at question. However, other reasons are indicated as producing favorable results from the diet (9, 10). In Dr. Feingold's regime (5), the entire family life-style is centered around the change of diet. Since hyperactive behavior is often associated with family problems and lack of attention, the alterations in family responses may be partially related to improvement in the child (9, 10).

There is a suggestibility factor in evaluating results of improvement of hyperactive symptoms from the K-P diet. The confident expectations generated in the child and the family may affect the syndrome itself, or the parent's ratings of the altered behavior (9). Also, when parents or teachers know particular children are on the diet, that knowledge may influence their ratings (9).

Conclusions

Only within the past three decades has hyperactivity become a household word, and this condition is now regarded as separate from mental retardation or insanity (1). While there are numerous behavioral, cognitive, and emotional characteristics associated with the hyperactive syndrome, the primary symptoms seem to include cognitive dysfunction, impulsivity, excessively high activity level, distractibility, and deficits in the attention process.

Definite causation of hyperactivity has yet to be determined. The single most accepted theory seems to be the disturbance of synapse transmission in the brain stem. However, research points to other causes of the hyperactive syndrome.

Because the syndrome itself and the causative factors are nonconclusive, a definite treatment has not been determined. Psychostimulant drugs are widely used, but many feel that they should be replaced by or supplemented with behavioral therapy. And, in addition, Dr. Feingold has contributed his controversial K-P diet as a method of relieving hyperactive symptoms in children. More studies need to be initiated to form conclusive results regarding the effectiveness of Dr. Feingold's diet. According to C. Simons, dietitian at Kaiser Hospital in Santa Clara, California, researchers from Kaiser Foundation and the University of California at Berkeley are currently examining the effectiveness of the additive-free diet on one- to six-year-old children with behavior difficulties (21).

Hyperactivity is a current problem for children, and many questions remain unanswered. Continuing research on cause, effects, and treatment is necessary to bring relief to the children who have the hyperactive syndrome and to their families.

Bibliography

1. Alabiso, F. P., and J. C. Hansen. The Hyperactive Child in the Classroom. Springfield, Ill.: Charles C. Thomas, 1977.

2. Campbell, S. B., and others. "Cognitive Styles and Hyperactive Children and the Effect of Methlyphenidate," Journal of Child Psychology and Psychiatry, 1 (1971), 55-67.

3. Cantwell, D. P. "Familial-Genetic Research with Hyperactive Children," The Hyperactive Child. Ed. D. P. Cantwell. New York: Spectrum Publications, Inc., 1975.

4. Conners, C. K., and others. "Food Additives and Hyperkinesis: A Controlled Double-Blind Experiment," Pediatrics, 58 (August 1976), 154-166.

5. Feingold, B. F. Why Your Child is Hyperactive. New York: Random House, 1975.

6. Fish, B. "Stimulant Drug Treatment of Hyperactive Children," The Hyperactive Child. Ed. D. P. Cantwell. New York: Spectrum Publications, Inc., 1975.

7. Gofman, H. "The Physician's Role in Early Diagnosis and Management of Learning Disabilities," Learning Disabilities. Ed. L. Tranopol. Springfield, Ill.: Charles C. Thomas, 1970.

8. Harley, J. P., and others. "Hyperkinesis: Food Additives and Hyperkinesis in Children." Paper presented at the annual meeting of the Food and Nutrition Liaison Committee, Nutrition Foundation, Naples, Florida, January 1976.

9. Institute of Food Technologists' Expert Panel on Food Safety and Nutrition. "Diet and Hyperactivity: Any Connection?" Food Technology, 30 (April 1976), 29-34.

10. Larkin, T. "Food Additives and Hyperactive Children," FDA Consumer, 11 (March 1977), 19-21.

11. Lucas, B., and C. J. Sells. "Nutrient Intake and Stimulant Drugs in Hyperactive Children," Journal of the American Dietetics Association, 70 (April 1977), 373-377.

12. Mendelson, W., and others. "Hyperactive Children as Teenagers: A Follow-up Study," Journal of Nervous and Mental Disease, 4 (1971), 273-279.

13. Miller, J. S. "Hyperactive Children: A Ten-Year Study," Pediatrics, 61 (February 1978), 217-222.

14. Minde, K., and others. "The Hyperactive Child in Elementary School: A Five-Year, Controlled Follow-up," Exceptional Children, 38 (1971), 215-221.

Bibliography (Continued)

15. Morrison, J. R., and M. A. Stewart. "Evidence for Polygenetic Inheritance in the Hyperactive Child Syndrome," American Journal of Psychiatry, 130 (July 1973), 791-792.

16. National Advisory Committee on Hyperkinesis and Food Additives, Report to the Nutrition Foundation. New York: Nutrition Foundation, 1975.

17. O'Leary, S. G., and W. E. Pelham. "Behavior Therapy and Withdrawal of Stimulant Medication in Hyperactive Children," Pediatrics, 61 (February 1978), 211-217.

18. Palkes, H., and M. Stewart. "Intellectual Ability and Performance of Hyperactive Children," American Journal of Orthopsychiatry, 42 (January 1972), 35-39.

19. Reichard, C. C., and S. T. Elder. "The Effects of Caffeine on Reaction Time in Hyperkinetic and Normal Children," American Journal of Psychiatry, 134 (February 1977), 144-148.

20. Safer, D., and others. "Depression of Growth of Hyperactive Children on Stimulant Drugs," New England Journal of Medicine, 281 (August 3, 1972), 217-220.

21. Simons, C. Personal interview. Santa Clara, California, April 24, 1978.

22. Smith, L. "Diet and Behavior." Address at the Association of California School Administrators (Northern Branch) Conference, San Francisco, California, December 11, 1977. Tape available at Santa Clara County Office of Education.

23. Sprague, R. L., and others. "Methylphenidate and Thioridazine: Learning Reaction Time, Activity and Classroom Behavior in Disturbed Children," American Journal of Orthopsychiatry, 40 (July 1970), 615-628.

24. Weiss, G., and others. "Comparison of the Effectiveness of Chloropromazine, Dextroamphetamine, and Methylphenidate on the Behavior and Intellectual Functioning of Hyperactive Children," Canadian Medical Association Journal, 104 (January 9, 1971), 21-25.

CHAPTER 9

Synergistic Interaction of Malnutrition and Infection

The relationship between malnutrition and infection frequently results in a vicious cycle. Malnutrition predisposes to infection, which, in turn, produces a greater degree of malnutrition (10). Authorities describe this cycle as a synergistic relationship between malnutrition and infection. The infectious process often results in a deterioration in the individual's nutritional status; conversely, the individual with poor or borderline nutritional status tends to have an increased incidence of infections and a prolonged, more severe course of illness (10). The most important synergistic reactions occur in children as they are in the formative years, often producing permanent deficits in physical and mental development (11).

The interaction between malnutrition and infection is repeatedly demonstrated clinically and epidemiologically in children from developing countries (7, 10). However, children of the United States inner-city ghettos, Indian reservations, migrant camps, and poor rural communities have much in common with their counterparts living in poverty in other countries (4).

Poor nutritional status is rarely an isolated problem, but has a multifactoral etiology (4). The common, and often preventable, situations occurring along with malnutrition are the poor housing, overcrowded conditions, inadequate sanitation and contaminated water supply that result from low socioeconomic circumstances (4). These conditions, associated with poor nutritional status, often contribute to the spread of disease.

Effect of Infection on Nutritional Status

Infectious diseases have adverse effects on many aspects of human life, but the nutritional state is the most apparent (7). Infections, whether bacterial, viral, fungal, or parasistic, are accompanied by a wide variety of symptoms, some of which have considerable bearing on an individual's nutrition. Low- or high-grade fever, more rapid pulse rate, restlessness, tachypnea, irritability, and even delerium or convulsions may occur. Often general distress and discomfort may cause malaise and anorexia (4).

The diagram in Figure 9 indicates the sequence of nutritional responses that evolve during the course of an infectious disease (2). Many of these metabolic responses can be detected during the incubation period of an infectious disease if appropriate laboratory studies are conducted before the onset of the clinical manifestations (1). Thus, the seriousness of the responses to follow are lessened. Although the responses may vary from one infection to another, they are generally consistent in their order of appearance (4).

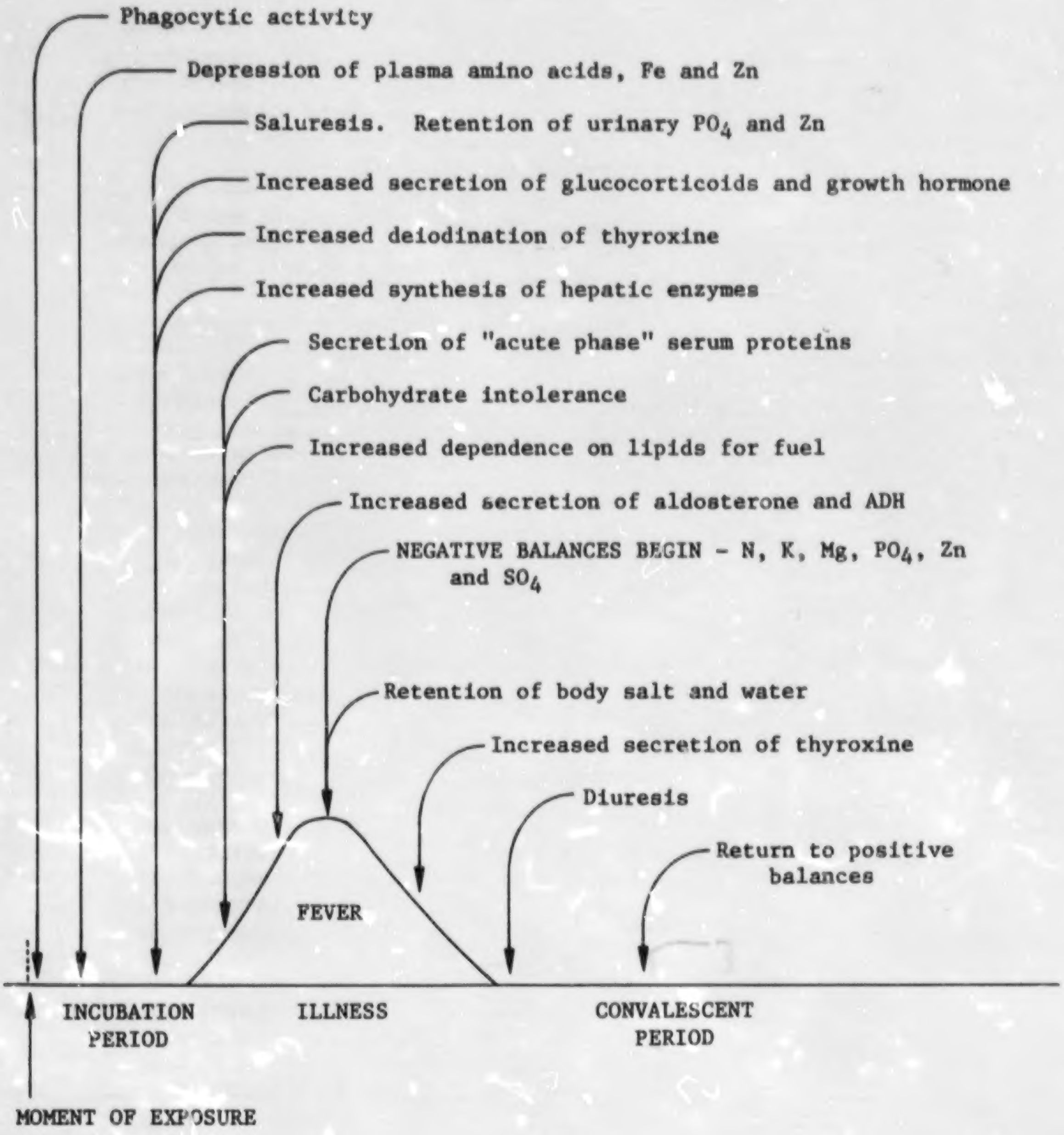

Phagocytic activity
Depression of plasma amino acids, Fe and Zn
Saluresis. Retention of urinary PO_4 and Zn
Increased secretion of glucocorticoids and growth hormone
Increased deiodination of thyroxine
Increased synthesis of hepatic enzymes
Secretion of "acute phase" serum proteins
Carbohydrate intolerance
Increased dependence on lipids for fuel
Increased secretion of aldosterone and ADH
NEGATIVE BALANCES BEGIN - N, K, Mg, PO_4, Zn and SO_4
Retention of body salt and water
Increased secretion of thyroxine
Diuresis
Return to positive balances
FEVER
INCUBATION PERIOD
ILLNESS
CONVALESCENT PERIOD
MOMENT OF EXPOSURE

Figure 9

Host Nutritional Responses to Infection

Source: (2)

Protein

The most important nutritional consequence of infection seems to be an alteration in the protein metabolism of the host. All defensive mechanisms the host uses to combat the infectious process are ultimately dependent upon the ability of the host tissues to manufacture key proteins in sufficient quantity for cellular and tissue repair (1). Despite the importance of protein synthesis, the major nutritional problem results from the acceleration of protein catabolism, or the breaking down of body protein. The catabolic effects on a child's muscle tissue are often so visible that a wasting of body tissue appears as a response to severe infection (1).

Most bacterial and viral infections have adverse influences on the body's nitrogen balance, especially after the onset of the febrile response (1, 11). Changes in the rates of both intake and loss of nitrogen contribute to the negative balances. Anorexia generally causes the decreased intake of food, and the body is not able to adapt rapidly to conserve its nitrogen stores so that more of this element is excreted in the urine. A large amount of body nitrogen from protein catabolism is also excreted (1).

In intestinal infections, protein absorption and retention are impaired, thus allowing more nitrogen loss (11). Even chronically infected tonsils exert a marked protein catabolic effect leading to a negative nitrogen balance (6).

Vitamins

The most dramatic demonstration that infections may precipitate acute vitamin deficiencies is related to vitamin A insufficiency, which leads to blindness. The quantity of vitamin A in the blood and the amount excreted in the urine of malnourished children who had infections revealed acute signs of clinical vitamin A deficiencies (6, 11). Because low intakes of vitamin A are common in human diets, the direct effect of infection on vitamin A metabolism is of practical importance (10).

Infections also affect thiamine metabolism. Severe infection with fever lowers the thiamine pyrophosphate level as much as 50 percent, especially if fever and anorexia have been present a week or longer (11). Results of studies on laboratory animals and man show that infectious disease precipitates clinical beriberi in persons receiving a diet inadequate in thiamine (10).

In tapeworm infections, megaloblastic anemia often results from the parasite's high requirement for vitamin B12 (10). The role of intestinal flora is important in synthesizing vitamins; so changes in the flora due to infection may directly affect the supply of other B vitamins and vitamin K (11).

Minerals

Infections also contribute to mineral deficiencies, iron in particular. The effects of acute infections on iron metabolism in man are well documented, although some of the mechanisms are only partially understood (10). Infections influence iron metabolism in two ways. The first is through loss of blood, generally resulting from intestinal parasites. The second is through a syndrome called the "anemia of infection" (10, 11). The anemia appears with chronic infections which interfere with iron-binding capacity and erythrocyte life span (10, 11).

Numerous infectious diseases cause diarrhea and profound disturbance of the electrolyte balance. Potassium and chloride are the primary minerals lost (4, 10, 11). Calcium and phosphate metabolism have also been affected by infection, but the results are less remarkable (11).

Growth

Growth and development are frequently used as indicators of the nutritional status of children. Infectious disease in conjunction with reduced food intake and an altered metabolism of protein and specific nutrients is associated with retardation of growth and maturation (10)...The Oxford Child Health Survey of randomly selected groups of children, including those of lower economic status, showed that reduced growth and retardation were directly proportionate to the incidence of morbidity (11). Other investigations of the effects of infections on select groups of well-nourished children failed to demonstrate any interference with growth (11). Recent studies on immunizing children showed some interesting results in relation to the influence of infection on nutritional status. Children who were immunized with certain vaccines showed a lower weight gain following the innoculations (3). Although the decreased weight gains were not of alarming proportions, they were of such a degree that could cause the transfer of a child with grade II malnutrition into grade III. This reaction to the immunizations was compared to the body's reaction to low-grade infection (3).

Effect of Malnutrition on the Resistance to Infection

Malnutrition predisposes the individual to many infectious diseases of the gastro-intestinal and respiratory systems, to communicable viral diseases, such as measles, chicken pox, small pox, and to such bacterial diseases as rheumatic fever and tuberculosis (6). Among children in whom protein-calorie malnutrition is widely prevalent, the effect of severe malnutrition on infection has been shown time and again (6). Deficiencies in cellular immunity and anti-body responses considerably lower resistance to infection.

Cell-Mediated Immunity

Cell-mediated immunity involves the immune responses of phagocytosis and lymphocyte-mediated action, such as delayed hypersensitivity and intra-cellular killing. Protein malnutrition results in atrophy of lymphoid tissues, liver, spleen, and bone marrow from which phagocytes and lymphocytes originate (4).

The thymus-dependent lymphocyte (T cell) plays an important role in the body's defense against certain infections. Studies have shown that thymus atrophy and a reduction of peripheral lymph nodes, tonsils, the spleen, and the circulating lymphocytes occur in malnourished children (4). These children also have greatly increased rates of serious complications and mortality rates resulting from illnesses (10).

The cellular immune function was assayed in a group of malnourished Ghanaian children, aged six months to six years, along with age-matched controls. The results indicated that cell-mediated immunity was depressd in relation to the severity of protein-calorie malnutrition and may have contributed to the severity of infection that developed in the malnourished children (9).

Severe malnutrition may include protein, calorie, vitamin, or mineral deficiencies, all of which contribute to the depression of the cell-mediated immune response. However, with nutritional therapy, recovery of cell-mediated immunity promptly occurs (4).

Immunoglobulin and Antibody Responses

Immunoglobulin and antibody responses are generally impaired in malnourished children. Elevated serum levels of IgA, IgM, and IgG are usually evidenced (10). Most antibody responses of under-nourished children to antigens have been found adequate; however, response to certain antigens, such as influenza, typhoid fever, and yellow fever has been impaired (4).

In a group of malnourished children, low levels of specific antibodies were detected in response to a wide range of antigens. The low response was attributed either to low affinity-binding antibodies or to the inability of the antibody-synthesizing cells from malnourished individuals to incorporate the correct amino acids into the variable portion of the immunoglobulin molecule, a property which is essential for specific antibody formation (8). Studies by Chandra (5) showed impaired antibody responses in malnourished children might contribute to slow and inadequate recovery from viral and enterobacterial infections and predispose this group to life-threatening complications.

Experimental animal studies have indicated certain deficiencies of pyridoxine, vitamin A, and pantothenic acid may influence the suppression of the immune response and the production of antibody-forming cells. Whether these specific nutrients react in the same way in humans because of the lack of the same controls in human studies is not yet possible to determine (4).

When malnutrition occurs in an unborn or newborn child, the effects are more pronounced and prolonged on the immune response as a whole (8). In older children with malnutrition, but without any evidence of infection, the serum immunoglobulins are usually normal. However, those having both malnutrition and infection showed elevated serum immunoglobulin levels. Specific antibody production to a wide range of antigens is below normal, and there is evidence that immunizations of children may not be effective during a period of severe malnutrition (8).

Iron Deficiency

Iron deficiency, which has been shown to depress bactericidal activity of leukocytes, is another factor in the production of an immuno-deficient state (4). The host and the microorganism compete for the iron, but many microorganisms are successful in binding certain metals, such as iron, copper, and zinc. However, an important defense mechanism of the host against microbial infection is the iron-binding proteins, such as lactoferrin and transferrin. Both inhibit microbial growth by reducing the availability of iron (4).

Epethelial Tissue Protection

Epithelial tissues in the body also maintain a defense against potentially invasive organisms, especially in the respiratory and gastrointestinal tracts. Deficiencies of vitamins A and C and riboflavin affect the condition of the epithelial tissues, thus allowing the invasion of infection (4, 11).

Management and Prevention

Within many cultural groups of the United States, there are traditional classification systems for types of diseases and foods, some of which influence treatment of infections (4). Many Chinese-Americans believe the Yin and Yang classification of food and drink contributes to the maintenance of the "internal balance" (4). Similarly, persons of Hispanic origin believe in a balance between "hot and cold" foods as a dietary management of certain infections. (Illnesses classified as cold are treated with hot medications and foods, whereas illnesses classified as hot are treated with cool substances.)

Other practices, often resulting from misinformation, include severe intake limitations, particularly of protein foods, a practice which has a detrimental effect on nutritional status. Some customs include administering only clear liquids to a child with diarrhea or restricting food intake to the febrile child. Another common practice is to withhold milk from children with coughs because of the belief this liquid causes phlegm annd mucus (4). Care should be taken in dietary counseling not to offend a family with strong convictions about feeding practices, but intervention is necessary for certain harmful dietary modifications.

To make an impact on prevention, the cycle of infection and malnutrition must be approached in both directions: immunizing against the precursors of infectious diseases and improving the nutritional status of children (10). Although popular literature exists regarding the positive effects of health foods and special diets in preventing infections, clinical studies show little conclusive evidence to support the notions (4). Megavitamin therapy and the consumption of high protein supplements, both of which can be dangerous to children, are popular theories of resistance to infection, but studies show these substances offer little concrete results of improvement. Data from some clinical studies present evidence that high blood levels of ascorbic acid have a pharmacologic effect as a nasal decongestant and help decrease symptomatic congestion (4).

Conclusions

Resistance to infection is determined by a great many interrelated factors, but one of the most significant variables is the nutritional status of the host. The interaction between nutrition and infection is described as synergistic: Malnutrition reduces resistance to infection; and infection, in turn, negatively affects nutritional status (4). Further, infections are likely to have more serious consequences among persons with clinical or subclinical nutrition, and infectious diseases have the capacity to turn borderline nutritional deficiencies into severe malnutrition (8).

Bibliography

1. Beisel, W. R. "Magnitude of the Host Nutritional Responses to Infection," The American Journal of Clinical Nutrition, 30 (August 1977), 1236-1247.

2. Beisel, W. R. "The Influence of Infection or Injury on Nutritional Requirements during Adolescence," Nutritional Requirements in Adolescence. Eds. J. I. McKigney and H. N. Munro. Cambridge: The MIT Press, 1976.

3. "Body Weight and Immunity - A Reciprocal Relationship?," Nutritional Reviews, 36 (February 1978), 41-43.

4. Brown, R. E. "Interaction of Nutrition and Infection in Clinical Practice," Pediatric Clinics of North America, 24 (February, 1977), 241-252.

5. Chandra, R. K. "Reduced Secretory Antibody Response to Live Attenuated Measles and Poliovirus Vaccines in Malnourished Children," British Medical Journal 2 (June 14, 1975), 583-585.

6. Gopalan, C., and S. G. Srikantia. "Nutrition and Disease," World Review of Nutrition and Dietetics, Vol. 16. Ed. M. Rechcigl. Basel: S. Karger, 1973.

7. Mata, L. J., and others. "Effect of Infection on Food Intake and the Nutritional State: Perspectives as Viewed from the Village," The American Journal of Clinical Nutrition, 30 (August 1977), 1215-1227.

8. McFarlane, H. "Nutrition and Immunity," Present Knowledge in Nutrition. Ed. D. M. Hegsted. Washington, D. C.: The Nutrition Foundation, Inc., 1976.

9. Neumann, C. G., and others. "Immunologic Responses in Malnourished Children," The American Journal of Clinical Nutrition, 28 (February 1975), 89-104.

10. Scrimshaw, N. S., C. E. Taylor, and J. E. Gordon. Interactions of Nutrition and Infection. Geneva: World Health Organization, 1968.

11. Taylor, C. E., and C. Desweemer. "Nutrition and Infection," World Review of Nutrition and Dietetics, Vol. 16. Ed. M. Rechcigl. Basel: S. Karger, 1973.

CHAPTER 10

Growth and Malnutrition

Results from studies reveal that malnutrition prevents children from achieving their optimum physical growth and mental development.

Anthropometric Assessment

Anthropometric measurements are useful in identifying populations whose nutritional inadequacies are reflected in retarded growth and development. However, very strictly speaking, anthropometry does not specifically assess only the effects of malnutrition on the body, as genetic and disease factors are not yet quantifiable as additional influences on growth and development (10).

A number of simple or composite anthropometric indices are used, such as arm and head circumferences, weight, height, and age (10). However, a study conducted by the Bureau of Training of the Center for Disease Control at public health clinics in various states revealed that a significant proportion of anthropometric measurements incorporated serious errors due to inaccurate instruments, poor technique, incorrect readings, or inaccurate recording (15).

Although anthropometric measurements are widely used in younger children, they are generally less suited to older children. During adolescence a spurt in bodily growth together with development of the reproductive organs and many other physiological changes in both sexes occur. The time at which the growth increase begins and its intensity are obviously influenced by nutrition, which is only one of several factors. Because of the complexity of the changes, adolescence does not seem to be an age particularly suited for nutritional surveillance (10).

To determine the extent of malnutrition in children, several measures of anthropometric assessment are used: arm circumference, weight-for-age, height-for-age, and weight-for-height. An examination of these measures follows.

Arm Circumference

Arm circumference, a measurement taken around the midpoint of the upper arm, is an indicator of the nutritional status in children (10, 13). In small children, this indicator is not always reliable because 80 percent of the measurements are in a range of about 3.0 cm. If the margin of error in taking the measurements is approximately 0.5 cm. in both directions, the variation, without the use of very large populations, could be significant (10).

Some advantages of using mid-upper arm circumference measurements are that thin limbs are clinically obvious in malnutrition and probably reflect stores of protein and fat. The upper arm is easily accessible for simple and rapid measurement with inexpensive, easily transportable, and nonbreakable apparatus. Also, the upper arm is less affected by edema, often present in kwashiorkor (9).

The arm circumference related to height (QUAK stick) is used as a quick classification of malnourished children in field operations. This measure is fast and simple and needs no complicated equipment, but the procedure requires careful training of workers (10).

In a recent study, the growth in arm muscle and arm fat of preschool children from rural Guatemala was compared with a standard of these measures from the United States. Arm circumference and triceps skinfold measurements (described on page 79) were taken, and the data indicated the Guatemalan children had less arm fat than those from the United States. Another finding from the study was that lack of calories rather than protein was the main nutritional deficit (11).

The anthropometric status of low- and middle-income preschool children participating in Hawaiian day care centers was evaluated by the use of mid-arm circumference (13). No significant differences were documented between the low- and middle-income groups. However, differences were noted when the right or left side of the body was compared for measurements, indicating a need to specify which side of the body was to be included in the standards of reference (13).

Weight-for-Age

The measurement of body weight is the simplest, most direct, and most common assessment of growth in children (10). If a single measurement of weight is used to assess nutritional status, this amount must be compared with a reference which is the weight of a "normal" child of the same age (10). The most popular way to classify the distributions of values in the reference population is to use percentiles of the population as comparison (10).

In addition to the need to define and locate a reference population, there are other disadvantages with the use of weight-for-age as a measure of nutritional status. The first is that children with edema would not show a weight deficit. Therefore, symptoms of malnutrition in a child might not be recognized. The second is that even in a case of severe malnutrition, a person could be taller than normal if his or her stature had developed during a period of adequate nutrition. This individual would be within normal limits for weight because of the weight of the skeletal system (10).

Weight data in the Ten-State Nutrition Survey (14) indicated an excess of both underweight and overweight children in relation to the standard, suggesting that malnutrition exists as a result of either undereating or overeating. There were more underweight chilren who fell below the 15th percentile in both the younger age and the lower income groups. Children in the higher income groups were generally taller and heavier and had larger fatfold measurements than those in the lower income groups (14). Other anthropometric data from X-ray measurements, such as estimated skeletal weight and appearance of ossification centers, also suport the findings of more advanced growth and development in persons of higher income status (14).

A child's weight at birth is a factor influencing later growth rate (3, 10). In countries where malnutrition is common, a large proportion of children are born with a weight under 2.5 kg. For example in Guatemala, 13 to 40 percent of newborns weighed less than 2.5 kg. (3).

Height-for-Age

Height-for-age, on the other hand, is used to indicate the nutritional status of children. This technique can estimate past and chronic malnutrition, but not necessarily the present nutritional status (10). There are several factors which make the use of height-for-age unsatisfactory as an indicator. First, the distribution of height is usually narrow. In a study of British preschool children, the third percentile was only 7 to 8 percent below the median, a fact that makes classification difficult (10). Other disadvantages include genetic factors which affect height and the length of time required to create a height deficit. These conditions make height an unsuitable gauge for very young children (10).

Studies by Cravioto and DeLicardie (3) indicate that, if height-for-age measurements were markedly low upon a child's hospital admission, stunting was present for several years, even if home conditions were favorable to meet the requirements of rapid growth. Since a child needs 81 kilocalories to form 10 grams of new tissue containing 1.7 grams of protein and 2.5 grams of fat, low-income undernourished children may have difficulty receiving an adequate diet at home so that they can reach their full growth potential (3).

Weight-for-Height

A more reliable indicator of thinness or fullness is the use of an index of weight-for-height. Since the common reference standards do not express an age difference, weight-for-height is expressed as a percentage of the reference median-weight-for-median-height at each age (10). The age independence makes this technique easy to use with groups whose ages are uncertain.

Weight-for-height values of a child population grouped by height-for-age classes probably provide the maximum information regarding the nutritional status obtainable from weight, height, and age categories. The combination of values offers a better indication of total nutritional status, both past and present (10).

Nutritional assessment of rural Indian children by Rao and Rao (12), who used a weight-for-height index, showed that children with signs of protein-calorie malnutrition had significantly lower gains in both height and weight than the apparently normal children. Data from studies of the heights and weights of children in southern Tunisia showed that environmental factors are stronger determinants of growth than are genetic attributes (8). Of the environmental factors, nutrition is the most important determinant. Although protein deficiency beginning in infancy appeared as the major factor of growth retardation in southern Tunisian children, calorie inadequacy is the main nutritional constraint on growth (8, 11).

Upon recovering from undernutrition, children may return to the weight and height percentiles of their previous growth pattern provided that the period of illness was not so severe as to permanently affect the recovery process. Such "catch-up" growth is rapid under favorable circumstances of rehabilitation. The rates of gain exceed those of a healthy child of the same age (7). Studies of the rehabilitation process in malnourished children show that once the expected weight-for-height is reached, the increased appetite abates; and intake drops to levels comparable to those of normal children of similar status (7, 10).

Cravioto and DeLicardie (3) emphasize that a severe acute episode of malnutrition that causes a child to enter the hospital has little influence on subsequent growth after discharge. But chronically malnourished infants, with or without an acute episode of deficiency, would not reach the norms of growth of their class for many years (3).

Brain Development

Malnutrition, reflected in chronic limitation of amounts of food consumed, results in general stunting of growth accompanied by reduced brain size, decreased brain cell number, and immature or incomplete biochemical organization of the brain (6). Development of the human brain, as other parts of the body, is a result of both genetic factors and environmental influences. There are internal and external influences on brain development. Malnutrition is one of the most important, potentially harmful internal bodily alterations that affect normal brain development (2).

There are many biochemical structural alterations that are associated with impaired brain function. These include loss of certain types or total numbers of brain cells, impaired myelin formation, altered protein synthesis, altered glycosaminoglycan formation, reduced cell size or number of axondendritic connections, impaired formation of neurotransmitters, and other changes that are not fully understood (2).

In examining the possible alterations in brain development, researchers have difficulty because animal experiments are often used for results dependent upon controls which are not possible with humans. Recognizable differences exist, however, between experimental animals and humans in the timing of brain development. These differences allow many similarities in comparison (2). Much investigation is dependent upon available human specimens from nonsurvivors of malnutrition. The results from these specimens are representative of the extremes (2). The concept of "critical time periods" in organ development refers to a stage of rapid growth which cannot occur again at a later time (2). The critical period in brain development varies in timing for the various brain subparts, but comes between early fetal life and the fourth postnatal year (2). The choice of the fourth year as a cutoff is arbitrarily defined. However, clinical evidence, such as the discontinuation of the low-phenylalanine diet in children with phenylketonuria, suggests that insults after four years of age are not likely to permanently impair further brain development (2). There is some gradual increase in brain weight after age four years and some increase in head circumference until about eighteen years of age (2).

Within an organ as diverse in makeup as the brain, critical periods of development exist for individual parts. Neuronal cells form primarily in utero. Glial cells, in contrast, form during the first year of postnatal life. Myelin accumulates primarily in the second postnatal year (2). Thus, an insult during a particular period of development affects one brain parameter more than another. Figure 10 shows the normal periods of brain cell formation in humans. Approximately 25 percent of the number of total brain cells in the adult are also present at birth; 66 percent, by age six months; and 90 to 95 percent,

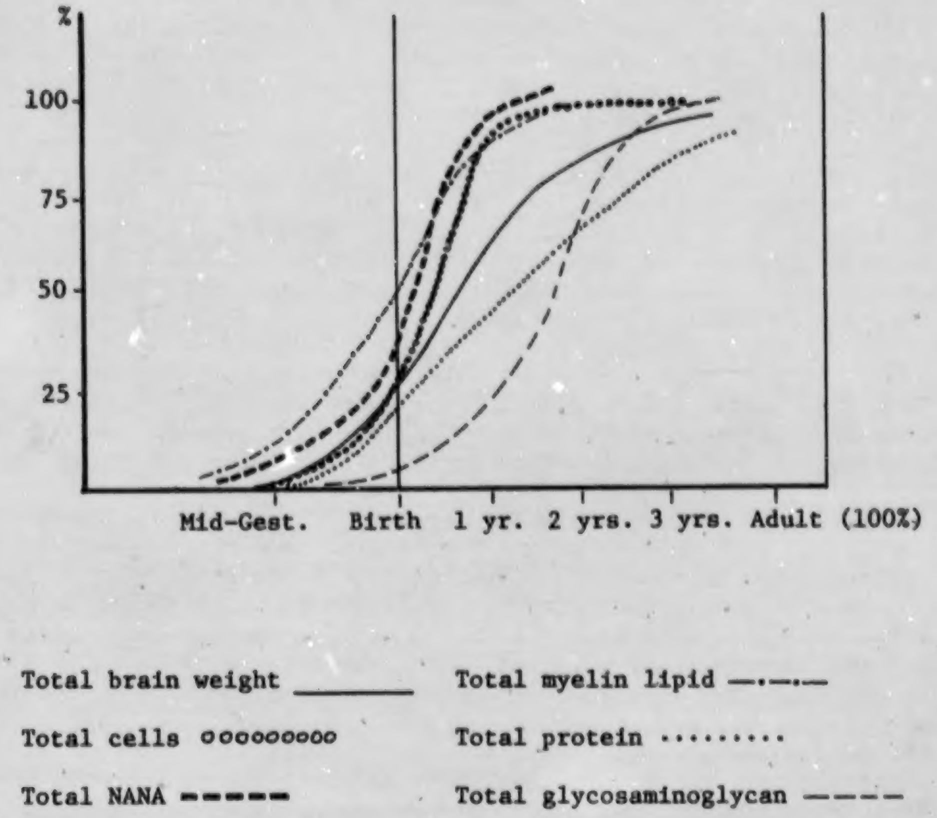


Figure 10

Normal Periods of Brain Cell Formation in Humans

Source: (2)

by age one year. The age when the final few brain cells form is not known, but many think they develop by age three years (2). Thus, the first year following birth is the time period in which the greatest percentage of cells develop (2).

Effects of Intrauterine Undernutrition

Intrauterine life is more apt to be deprived among undernourished populations; as many as 40 percent of newborn infants weigh under 2.5 kg. (2). This deprivation is related to a higher incidence of prematurity and small-for-date infants, both of which result in a greater incidence of neonatal problems, including influence on later intelligence (2). Between 30 and 50 percent of the small-for-age infants who survive eventually demonstrate impaired neurologic and intellectual development (1).

Intrauterine infections, as well as postnatal infections, affect brain development. Biochemical malfunctions, such as hypernatremia (resulting from diarrhea) and hypoglycemia (resulting from low birth weight), occur more frequently in malnourished children and can impair normal brain development (2). Endocrine dysfunction, such as hypothyroidism, is associated with poor mental development; and low serum thyroxine levels often accompany malnutrition (2).

Since the time period for formation of neuronal cells is primarily during the intrauterine stage, it is important to consider whether malnutrition at this time alters cell formation. Intrauterine undernutrition occurs in placental failure to deliver adequate nutrients to the fetus and also is a result of a poor maternal diet. Both conditions cause small-for-age infants (2, 6).

Results from studies of brain development in small-for-age infants showed total dioxyribonucleic acid (DNA), which represents the total cell number, was reduced by 11, 15, and 20 percent in the cerebellum, cerebrum, and brain stem, respectively (2). Since 10 percent of all newborn infants are small-for-age by definition, some reduction in brain cell number is probable during the intrauterine period. However, with adequate postnatal rehabilitation, brain cell recovery would probably occur during the period of postnatal cell division. This process indicates that the brain cells forming postnatally are of the same type as the cells developed during the intrauterine period (2).

Effects of Postnatal Undernutrition

Severe general malnutrition during early postnatal life will affect brain structure and disrupt normal chemical development. Measurements of ribonucleic acid (RNA), DNA, proteins, glycosides, lipids, enzyme activity, and neurotransmitters demonstrate this outcome (6).

The brain does not develop uniformly but shows definite periods of increased activity, or growth spurts, during which the brain is considered to be particularly vulnerable to nutritional insults. Undernutrition during the proliferative periods causes permanent stunting of brain growth (5).

The periods when postnatal malnutrition affects brain development are presented in Figure 10 (2). However, the relative importance of a reduction in the number of neurons or other cells is not certain, as the number required for optimal function is not known. An excess of neurons may exist in the normal brain (2).

A study by Winick and Rossi (16) described the levels of DNA in children who died from postnatal malnutrition. Of the nine Chilean children who, between the ages of two weeks and six months, succumbed to malnutrition, three were small at birth and had a reduction in brain DNA of over 50 percent. The other six infants had a reduction in brain DNA of approximately 20 percent, and their birth weights were unknown (16).

Additional studies by the same group examined other children who were severely malnourished during the first year of life. All had severe malnutrition and died between ages thirteen and twenty-four months. The total DNA levels of all malnourished infants were reduced in approximately equal proportions in the cerebrum, cerebellum, and brain stem (2).

Another research study by Chase (2) was conducted on brain cellularity of infants who were breast fed and were of near-normal birth weights. When these infants died between the ages of one and two years, their cerebrum-brain stem DNA was reduced by 10 percent; but the cerebellum DNA was unaltered. In this frequently occurring type of malnutrition, breast feeding provides adequate nourishment, however, as the maternal milk supply becomes inadequate and other quality protein foods are unavailable or not fed to the child, severe malnutrition occurs (12).

DeLevie and Nogrady (4) reported the results of animal and human studies and suggested that malnutrition within the first few months of life interferes with cell division, a process which may not respond to refeeding. As an infant develops further, malnutrition decreases the protein in each cell, thus reducing cell size and weight; the protein, however, may be restored following the child's return to an adequate diet.

Conclusions

Retarded growth and malnutrition are present in the children of the world, especially in the low-income groups of developing nations and of industrialized societies, such as the United States. Genetics, nutrition, disease, and other environmental factors, both subtle and obvious, affect growth and development in children.

Among all the early environmental factors, nutrition is the most important and influential. Studies show that most of a child's brain development occurs before the first year of life and that the process is completed before the age of four years.

After cellular brain growth ceases, the rest of the body continues its development in response to varying degrees of nutrient intake. Nutritional assessment with the use of anthropometry is the first step in detecting malnutrition in children.

Anthropometric measurements are used as a gauge for nutritional assessments of body size. Standardized references were created to compare the measurements of children with various combinations of weight, height, age, or arm circumference; however, for greater accuracy, there is a need for revision of standards to include other factors which are influential on growth, such as genetics and race.

Bibliography

1. "Brain Biochemistry and Intrauterine Growth," Nutrition Reviews, 31 (January 1973), 16.

2. Chase, H. P. "Undernutrition and Growth and Development of the Human Brain." Malnutrition and Intellectual Development. Ed. J. D. Lloyd-Still. Acton, Massachusetts: Publishing Sciences Group, Inc., 1976.

3. Cravioto, J., and E. R. DeLicardie. "The Effect of Malnutrition on the Individual," Nutrition, National Development and Planning. Eds A. Berg and others. Cambridge: The MIT Press, 1973.

4. DeLevie, M., and M. B. Nogrady. "Rapid Brain Growth Upon Restoration of Adequate Nutrition Causing False Radiologic Evidence of Increased Intracranial Pressure," Pediatrics, 76 (April 1970), 523-528.

5. Dobbing, J. "Effects of Experimental Undernutrition on Development of the Nervous System," Malnutrition, Learning and Behavior. Eds. N. S. Scrimshaw and J. E. Gordon. Cambridge: The MIT Press, 1968.

6. Food and Nutrition Board, Subcommittee on Nutrition, Brain Development and Behavior. "The Relationship of Nutrition to Brain Development and Behavior," Ecology of Food and Nutrition, 2 (1973), 275-280.

7. Forbes, G. B. "Mathematical Models for the Analysis of Human Growth, " Proceedings of the Ninth International Congress on Nutrition, Mexico 1972. Eds. A. Chavez and others. Basel: S. Karger, 1975.

8. "Heights and Weights of Children in Southern Tunisia," Nutritional Reviews, 33 (August 1975), 235-236.

9. Jelliffe, D. B., and E. F. P. Jelliffe. "The Quipu in Measuring Malnutrition," The American Journal of Clinical Nutrition, 28 (March 1975), 203-204.

10. Keller, W., G. Donoso, and E. M. Demaeyer. "Anthropometry in Nutritional Surveillance," Nutritional Abstracts and Reviews, 2 (August 1976), 591-607.

11. Martorell, R. M., and others. "Upper Arm Anthropometric Indicators of Nutritional Status," The American Journal of Clinical Nutrition, 29 (January 1976), 46-53.

12. Rao, K. V., and N. P. Rao. "Association of Growth Status and the Incidence of Nutritional Deficiency Signs," The American Journal of Clinical Nutrition, 28 (March 1975), 209-215.

13. Standal, B. R., and M. F. Tiangha. "Assessing the Anthropometric Status of Preschoolers Participating in Feeding Programs in Day Care Centers," The American Journal of Clinical Nutrition, 30 (December 1977), 2101-2107.

Bibliography (Continued)

14. U. S. Center for Disease Control, Atlanta. Ten-State Nutrition Survey 1968-1970. Department of Health, Education, and Welfare. Publication No. (HSM) 72-8131.

15. U. S. Center for Disease Control Nutrition Surveillance, Atlanta. Sources of Error in Weighing and Measuring Children. Department of Health, Education, and Welfare. Publication No. (CSC) 76-8295, 1975.

16. Winick, M., and P. Rosso. "The Effect of Severe Early Malnutrition on Cellular Growth of Human Brain," Pediatric Research, 3 (1969), 181.

CHAPTER 11

Behavior and Achievement as Related to Malnutrition in Animals

In their studies of the effects of malnutrition, Levitsky and Barnes cite certain advantages of using animals as subjects rather than humans (13). In the first place, the study is much more controlled. Diet control, time and degree of deprivation, social stimulus, and other environmental factors are manipulated with some degree of efficiency. This situation is not possible when man is used as the study subject. Secondly, when animals are used, they are deprived to their limits so that, symptoms of severe malnutrition develop. Lastly, the cost of animal studies is much more reasonable than human studies (13). Whether the results obtained from animal studies apply to humans is a problem that may be difficult to resolve. One observes the performance of an animal to evaluate the degree to which a particular animal is stunted intellectually because of malnutrition (23). Unfortunately, performance is not the result of learning alone. Motivation, the reinforcement used, and the emotionality of the animal are reflected in the animal's performance. If results of studies are to be of value, these variables must be kept as constant as possible (13).

Animal studies continue to reveal the harmful effect of dietary deprivation on the later performance of the animal. The cat, the dog, the pig, and the mouse have all been used for experimentation, but the greatest volume of information has resulted from experimentation with the laboratory rat (1).

Periods When Malnutrition Proves Most Detrimental

The "vulnerability period" (17:39) idea that was advanced by Dobbing suggests that periods of rapid growth or the so-called "brain growth spurt" (17:30) are the times when an animal would suffer severe effects from malnutrition (17). Through his experiments, Dobbing determined that deprivations at these periods affect the structure of the nervous system (8) and, depending on the degree of deprivation, affect in particular the weight of the adult brain (9). Winick revealed that the number of cells in the whole or a certain part of the brain was reduced (22), and Dobbing showed that the degree of myelination (7) diminished in the brains of those rats that were deprived during vulnerable periods.

Restricted access to the mother rat's milk, increased litter size, decreased protein content of the mother rat's diet, or reduced amounts of food available to the mother cause food deprivation of the rat offspring (14). In 1968 Cowley found that the nutritional history of the maternal rats from previous generations was another factor that influenced the behavior of the offspring (5). Whether this discovery was just the result of cumulative poor nutrition or whether the abnormal interaction between the mother rat and the young caused the change in the offsprings' behavior prompted further study (5).

The usage of foster maternal rats in further studies suggested that, if the mother rat was malnourished, the effects were carried over to the pup, even if the pup had been nursed by a well-fed foster mother (4). Well-documented summaries of nutritional experiments on animals appear in the text, Nutrition and the Brain (15). These summaries include: the age of the animals at food deprivation, method of applying the food deprivation, severity of the deprivation, and results of the experiments.

Evidence of Changes in Behavior Caused by Malnutrition

To observe an animal's behavior is quite easy, but to interpret the behavior and its causes is a complex problem because malnutrition is just one of many environmental factors that cause behavioral alteration (21).

Classically, "emotionality" in rats has been tested by simply observing them in an open field. A rat is placed in a box with squares outlined on its floor. It is observed for a given period of time and the number of squares traversed (horizontal movement) as well as the number of times the animal rears up on its hind limbs (vertical movement) are recorded. The number of times the animal urinates and defecates is also recorded (21:131).

This technique has no system of reward or punishment; observation alone is required. Rats malnourished neonatally, during the nursing period, during the weaning period, after the weaning period, or any combination of these periods were tested as adults using the aforementioned "open field" test to determine whether the effects of early malnutrition extended into adulthood. Decrease in activity and increase in excretion of urine and feces are observed repeatedly (21). However, if the food deprivation was initiated in the post-weaning period only, the effect was not as evident (2, 9, 18). The reactions are described as a lack of exploratory activity and increased irritability (21). Cowley suggests (5) that the nutrition of previous generations is reflected in the behavioral responses of an animal. Previously malnourished rats were more sensitive to adverse stimulation,such as loud noises or electric shock (12).

Testing with pigs as the experimental animal showed results similar to the rat studies (3). An increase in emotionality of pigs was evidenced by their lessened exploratory activity and heightened attention toward food. The permanency of the behavioral changes seemed to be governed by the degree of food deprivation and the timing of the deprivation (2).

Primate models have also been used for testing. When these animals were deprived nutritionally, they assumed a very passive type behavior. They were less curious, played less, showed less sexual behavior, less grooming, and were less active in problem solving (10, 13, 21, 23).

Zimmermann (22, 23) concentrated on experimental work with the monkey. In all tests to evaluate behavior and achievement of the experimental monkey, he used a piece of equipment called the Wisconsin General Test Apparatus (WGTA). The animal was caged behind an opaque screen, and the experimenter was separated from the monkey by a one-way screen. Both screens were capable of manipulation. Thus the behavior of the monkey was observed following the introduction of various testing procedures. In one procedure, the test objects covered a food reward, and the results showed that the animals fed a low-protein diet (3.5 percent casein) reacted quite differently than did the well-fed animals (25 percent). The animals fed a low protein diet consistently scored lower in tests of conditional discrimination and reversal learning. In further tests the low-protein fed monkey showed less ability to discriminate between different types of stimuli. These tests led the experimenter to conclude that the food deprived monkey's performance resulted from a breakdown in attention (23).

Zimmermann summarizes the learning and perceptual task performance of the monkey in the following ways:

1. Those tests not affected
    a. Delay response
    b. Object discrimination
    c. Simple reversal learning
    d. Object quality discrimination learning
    e. Long- and short-term memory

2. Those tests in which low protein animal performance is inferior
    a. Pattern object reversal learning
    b. Central stimulus reversal learning
    c. Conditional discrimination learning
    d. Embedded figures discrimination
    e. Patterned strings, cross patterns (23:124)

When Winick summarized earlier studies, he stated that the undernourished animal was always dominated by the well-fed animal in social performance; however, if food was given as a reward, the underfed animal became extremely aggressive and dominant. It would again revert to the apathetic state if the food reward was removed (21).

When an animal is placed in an isolated environment, albeit fed correctly, the same symptoms develop as were evidenced with nutritional deprivation. Animal studies have shown that enriching the animals' environment helps to overcome the behavioral abnormalities which accompany malnutrition. This result indicates that malnutrition is just one of the environmental factors that influence behavior (13, 21) or that the "physiological mechanisms that may be responsible for the long-term effects of early stimulation may not be operative because of a concurrent state of malnutrition" (11:548). The schematic drawing in Figure 11 shows the concurrent pathways which account for similar results in behavior that occur because of nutritional and environmental deficiencies (19).

Evidence of Changes in Growth Caused by Malnutrition

Studies have shown that malnutrition does stunt the growth of dogs. If the malnutrition occurs during gestation, the newborns are undersized. When the pups were fed properly after weaning, most of the abnormalities disappeared, but some retardation of growth remained (18). When monkeys, beginning at four months of age, were used as test animals and the dietary protein

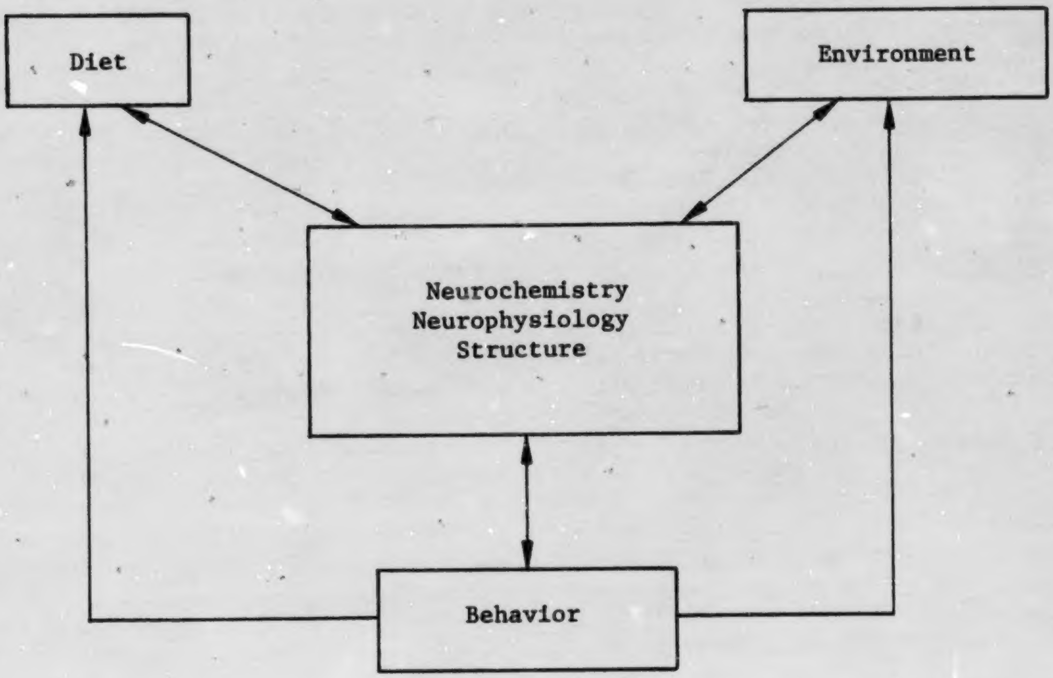

Diet
Environment
Neurochemistry
Neurophysiology
Structure
Behavior

Figure 11

Concurrent Pathways of Diet and Environment and Their Influence on Behavior

Source: (19)

was altered over a 50-month period, those on the low protein diet (3.5 percent casein) gained less weight than those on the high protein diet (2). These differences are depicted in Figure 12. Although other animals have been used as experimental subjects, the most frequently used test animal is the rat. This animal has been used in studies to determine the effects of varying degrees of malnutrition and various timing of food deprivation on growth rates.

Latest studies show that, if the rat is malnourished during gestation and then given to a normally fed foster mother, full growth is not attained (16). The rats exhibited catch-up growth during a period in their life cycle that would correspond to adolescence in the human, but they again fell behind when they reached adulthood (16). Similarly, if the rat was born of a healthy, well-nourished mother and then introduced either to a malnourished foster mother or to a mother nursing an oversized litter, insufficient growth was observed (16). This result is in agreement with earlier experimentation (1, 5, 6, 14, 17, 21). Malnutrition introduced after weaning has less discernable variances in growth (5, 14).

Evidence of Changes in Achievement Caused by Malnutrition

Historically, a maze-type test is used to measure an animal's ability to learn. Data reveal that the malnourished animal negotiates the maze in an inferior manner as compared with the well-nourished animal (1, 5, 6, 13, 20, 21). This inferior performance followed the animal into adult life. One major criticism of this type of testing is that food is often used as the incentive for performance (13, 21). The response of a hungry animal necessarily is quite different from that of a well-fed animal if food is used as motivation. However, researchers have shown that when other methods of motivation were used, such as cold water or electric shock, the results were the same (1, 10, 13, 21). From all methods employed, two problems arise when one tries to equate the degree and timing of malnutrition and the ability of the animal to learn. The first problem is that, although many types of behavior can be measured in the different species, the meaning of the behavior is often impossible to accurately determine and may or may not be due to a learning deficit. As noted previously in reference to behavior (page 164), isolation or lack of stimulation produces the same effect on achievement as does malnutrition (13, 21). The second problem is that malnutrition is a problem that never exists alone. To separate the results of the effect of malnutrition on the animal from the results of the other variables that accompany malnutrition is impossible (21). The concurrent independent and dependent variables related to undernutrition make it impossible to determine whether undernutrition alone affects later learning abilities.

Conclusions

Animal studies have contributed greatly to a rapid accumulation of knowledge concerning the relationship of nutrition and behavior, growth, and achievement. Results from these studies show that food deprivation during certain crucial periods of growth results in aberrant behavior which persists throughout the animal's life. These subjects exhibit less exploratory activity, increased excretion, and increased reaction to adverse stimuli. Moreover, all species exhibited decreased growth in comparison with controlled adults. The following quote from a recent (1976) publication by Winick aptly summarizes many years of research concerning malnourished animals and learning ability:

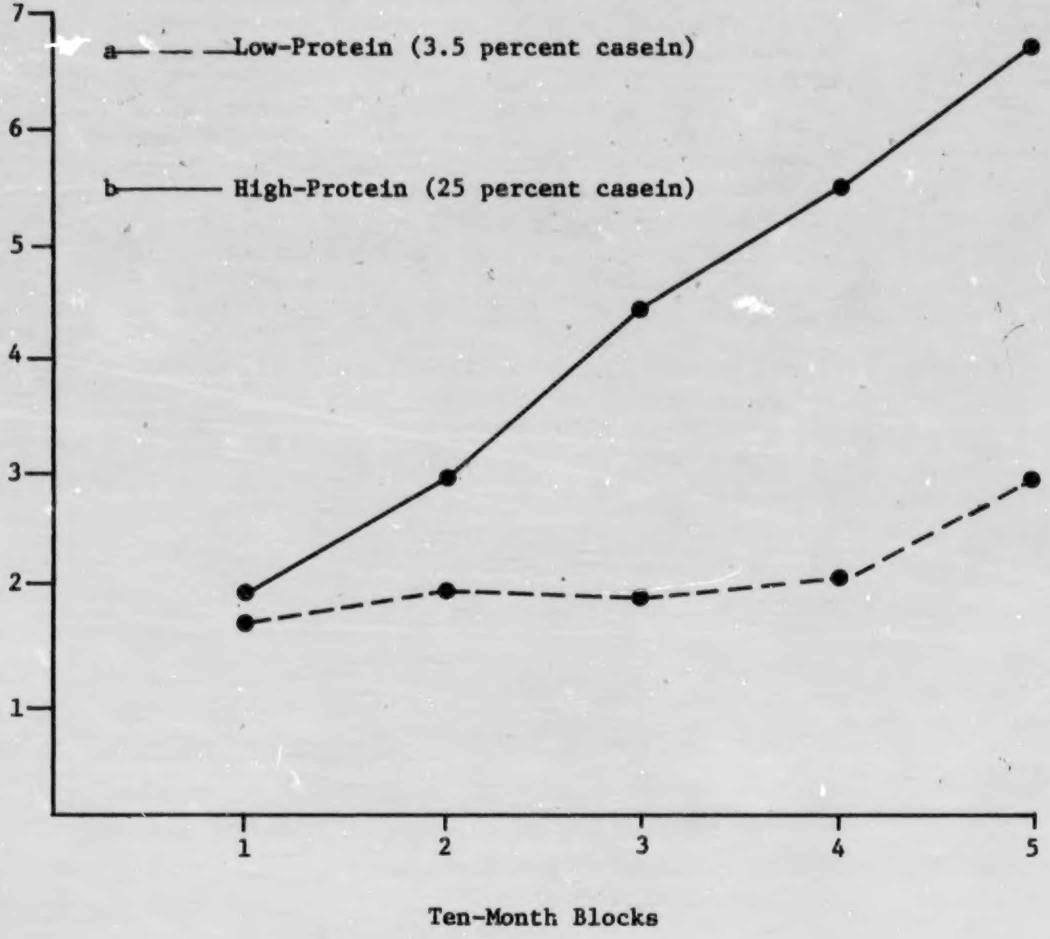


Figure 12

Comparison of Weight Gains by Monkey on Low and High Protein Diets

Source: (23)

In general then it can be said that the animal experiments have not proven an association between early malnutrition and learning. They have shown that animals malnourished in a variety of ways both prenatally and postnatally show behavioral abnormalities best described as increased emotionality and decreased exploratory activity. This behavioral pattern persists even after rehabilitation. Similar behavioral abnormalities have been induced in young animals by isolating them from their environment, and partial reversal of the effects of malnutrition is possible if the environment is enriched. After more than two decades of experiments the basic problems are still present. The animal experiments have certainly not solved the question of early malnutrition and later mental development, nor in my opinion can they ever solve this problem until the actual biochemical and neurophysiological mechanisms controlling specific behaviors are understood and the effects of malnutrition on these mechanisms studied. Thus the importance of animal behavior work in the future will be directly proportional to its use in deriving a better understanding of the basic mechanisms controlling behavior (10:136).

Bibliography

1. Altman, J. "Nutritional Deprivation and Neural Development," Brain Development and Behavior. Eds. M. B. Sterman, D. J. McGinty, and A. M. Adinolfi. New York and London: Academic Press, 1971.

2. Barnes, R. H., and others. "Effect of Food Deprivation on Behavioral Patterns," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts, and London: The MIT Press, 1968.

3. Barnes, R. H., A. V. Moore, and W. G. Pond. "Behavioral Abnormalities in Young Adult Pigs Caused by Malnutrition in Early Life," Journal of Nutrition, 100(2) (February 1970), 149-155.

4. Chow, B. F., and S. A. Miller. "Short Comments," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts, and London: The MIT Press, 1968.

5. Cowley, J. J. "Time, Place, and Nutrition: Some Observations from Animal Studies," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts, and London: The MIT Press, 1968.

6. Crnic, L. S. "Effect of Infantile Undernutrition on Adult Learning in Rats: Methodological and Design Problems," Psychological Bulletin, 83 (4) (July 1976), 715-728.

7. Dobbing, J. "The Influence of Early Nutrition on the Development and Myelination of the Brain," Proceedings of the Royal Society of London (Biology), 159 (1964), 503-509.

8. Dobbing, J. "Vulnerable Periods in Developing Brain," Applied Neurochemistry. Eds. A. N. Davison, and J. Dobbings. Oxford: Blackwell Scientific Publications, Ltd., 1968.

9. Dobbing, J., and M. C. Path. "Effects of Experimental Undernutrition on Development of the Nervous System," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts, and London: The MIT Press, 1968.

10. Kerr, G. R., and H. A. Waisman. "A Primate Model for the Quantitative Study of Malnutrition," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts, and London: The MIT Press, 1968.

11. Latham, M. C. "Protein-Calorie Malnutrition in Children and Its Relation to Psychological Development and Behavior," Psychological Reviews, 54(3) (July 1974), 541-565.

12. Levitsky, D. A., and R. H. Barnes. "Effect of Early Malnutrition on Reaction of Adult Rats to Adversive Stimuli," Nature, 225 (1970), 468-469.

Bibliography (Continued)

13. Levitsky, D. A., and R. H. Barnes. "Malnutrition and Animal Behavior," Nutrition, Development and Social Behavior. Ed. D. J. Kallen. Washington, D. C.: U. S. Government Printing Office, DHEW Publication No. (NIH) 73-242, 1973.

14. Rajalakshmi, R., and C. V. Ramakrishnan. "Nutrition and Brain Function," World Review of Nutrition and Dietetics. Ed. G. H. Bourne. Munchen, Paris, London, New York, and Sydney: S. Karger-Basel, 1972.

15. Shoemaker, W. J., and F. E. Bloom. "Effect of Undernutrition on Brain Morphology," Nutrition and the Brain. Eds. R. J. Wurtman, and J. J. Wurtman, Vol. 2. New York: Raven Press, 1977.

16. Smart, J. L., and others. "Nutritionally Small-for-Date Rats: Their Subsequent Growth, Regional Brain 5-Hydroxytryptamine Turnover, and Behavior," Pediatrics Research, 10(9) (September 1976), 807-811.

17. Sourander, P., A. Sima, and M. Haltia. "Malnutrition and Morphological Development of the Nervous System," Early Malnutrition and Mental Development. Eds. J. Cravioto, L. Hambraeus, and B. Vahlquist. Sweden: Almqvist and Wiksell, 1974.

18. Stewart, R. J. C., and others. "Nervous System Damage in Experimental Protein-Calorie Deficiency," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts, and London: The MIT Press, 1968.

19. U. S. National Academy of Science, The Relationship of Nutrition to Brain Development and Behavior. Washington, D. C.: National Research Council, June 1973.

20. Winick, M. "Early Malnutrition - Brain Structure and Function," Preventive Medicine, 6(2) (June 1977), 358-360.

21. Winick, M. Malnutrition and Brain Development. London, Toronto, and New York: Oxford University Press, 1976.

22. Winick, M., and A. Noble. "Cellular Response in Rats During Malnutrition at Various Ages," Journal of Nutrition, 89 (1966), 300.

23. Zimmermann, R. R., and others. "Attention Deficiencies in Malnourished Monkeys," Early Malnutrition and Mental Development. Eds. J. Cravioto, L. Hambraeus, and B. Vahlquist. Sweden: Almqvist and Wiksell, 1974.

CHAPTER 12

Behavior and Achievement as Related to Malnutrition in Humans

Although other factors influence a child's mental development, malnutrition is a major deterrent to a child's achieving his or her optimum mental growth.

Problems Encountered in Human Malnutrition Studies

Severe malnutrition is an accepted determinant of retarded growth, impaired learning, and aberrant behavior (6, 11, 30, 38). The attempt to assess the influence of lesser malnutrition on the individual presents a problem. Most often, undernutrition and malnutrition exist in combination with poverty. The special report issued by the Food and Nutrition Board aptly summarizes the scope of the problem:

> . . . malnutrition occurs primarily in poor environments in which many other forces may also limit the individual's development. In any event, malnutrition is detrimental in both good and poor environments but not necessarily equivalently so. (24:1)

Multifactoral Causation

Malnourishment does not directly result from inadequate food intake alone. This finding has been documented repeatedly (6, 11, 28, 30, 31, 38). Figure 2 (page 12), Figure 3 (page 24) and Figure 4 (page 25) show the complex intermingling of environmental factors. To isolate malnutrition from all the other factors is an impossibility (6, 11, 21, 28, 30, 31). Results from animal studies revealed the same problem when researchers tried to isolate malnutrition from other environmental factors (17, 38). The level of the motivation, the incentive value of the reinforcement, and the emotionality of the animal combine with the malnutrition to produce a certain type of performance. Studies of animals suggest that environmental factors also interrelate and influence the performance of man (38). Human controls, however, cannot ethically be employed when experiments involve physical and mental deprivation of the subjects. "Is it ethical, for instance, to give a child extra food for a while and then, when the research is completed, to allow him to revert to his former inadequate diet?" (19:102). Thus, ethics poses yet another problem when the effects of malnutrition on the achievement and behavior of man are examined (14, 17, 31). "Genetics, nutrition, disease, family and school stimulation, and other environmental effects, both subtle and obvious, all interact to affect mental capacity" (31:14).

Methodological Problems in Field Studies

All studies to determine the impact of nutritional status on behavior and/or achievement in man fall in the category of either retrospective or prospective (38). Retrospective studies examine one's present status and search for the causes of the present nutritional condition in the past. Prospective studies, which include both cross-sectional and longitudinal studies, examine one's present status and compare the individual with the group in terms of nutritional development over a long period of time.

The same multicausal factors that make the isolation of malnutrition from other environmental factors impossible also make the interpretation of test results most difficult (14). This interrelation of environmental variables clouds the data collection process and the interpretation of the data (13).

Evidence of Changes in Behavior

The effects of malnutrition, as related to behavioral changes, are generally categorized in terms of severity of food deprivation, namely, kwashiorkor, marasmus, or mild protein-calorie malnutrition. Kwashiorkor, resulting from a severe starvation state of protein, causes behavioral symptoms in children, such as extreme mental apathy, irritability, and a lack of interest in exploration. Further progression to a motionless state can develop. The implications of the state of kwashiorkor are not limited to the individual child, but lead to reduction of interaction between mother and child caused by reduced responsiveness (14, 25).

Marasmus, a strictly calorie deficient disease, is slightly less severe in its evidences on behavior. Although marasmus is a serious state of malnutrition, there is less mood alteration and less change in alertness (14).

In the United States, a mild-to-moderate state of protein-calorie malnutrition is more prevalent than kwashiorkor or marasmus. Although this condition is more common, it is more obscure in definition and documentation. Less measurable manifestations of general lethargy, apathy, and lack of interest in surroundings are observable (14). Unfortunately, present research concentrates on cognitive testing; and behavioral abnormalities, mood alterations, and deviant emotionalism are areas which researchers have not fully explored (14).

Change Resulting from Food Deprivation

Animal studies provide significant suggestions about human behavior caused by food deprivation. Humans, however, cannot be similarly studied because they cannot be caged, deprived, and observed as can an animal (31). So man must be observed first and, when abnormal behavior occurs, the cause must be found (26, 38). Human behavioral characteristics are historically defined as being the result of conditioning (24). Perkins (24) regards behavior more as a psychosocial manifestation and further postulates that behavior has a biochemical basis, such as nutrition. Moderate chronic undernutrition and hunger produce certain behavioral manifestations (11, 14, 28, 30). Factors which influence behavior are depicted in Figure 11 (page 113). The impact of the factors is not simply additive but rather is the result of a cumulative assault on behavior. The end results are the same, namely, apathy, lethargy, inability to pay attention, and perhaps overconcern for food. So the degree of behavioral abnormality is directly proportionate to the sum of the environmental factors of which malnutrition is just one (22). With this thought in mind, the following specific results of malnutrition are enumerated:

1. Shortened attention spans, lack of motivation, and lack of arousal are evidenced. Memory does not appear to be impaired.

2. Malnourishment leads to motor insufficiencies in children.

3. Sensory integration appears diminished (28).

Electroencephalogram

Electrophysiological activity of the brain, as measured by the electroencephalogram (EEG) test, has been measured using malnourished subjects. Abnormal EEG patterns are noted in both chronic and acute cases of malnutrition. The abnormalities disappear when adequate nutritional therapy is applied. No conclusive application can be made from this knowledge because research is not extensive in this area, but food deprivation may be a reason for abnormal behavior (22, 33).

Iron

Iron deficiency, rather than severe malnutrition, has emerged as the single most prevalent nutritional problem in the United States. This deficiency, because of its prevalence, must be considered in relation to behavior. While studying this concept, Pollitt and Leibel (26) found abnormal behavior in children who exhibited signs of anemia (hemoglobin less than 10 gm./100 ml. of blood). The abnormalities became apparent when the subjects were unable to perform adequately in tests which measured reaction time and attentive recall, and in cranking tasks. The anemic youngsters were unable to integrate effectively experience amassed during steps of the associative reactive test (26).

Well and Oski (37) observed twelve- to fourteen-year-old children from a mostly black community. The total group scanned for anemia consisted of 1,807 children; and, of the group, ninety-two were considered anemic. (Hemoglobin values ranged from 10.1 to 11.4 gm./100 ml. of blood.) Of the group of ninety-two anemic children, seventy-four were chosen for testing; and thirty-six control subjects were also selected from those children shown to be nonanemic. Both groups were scored by thirteen English teachers on a behavior problem checklist. The teachers did not know the identity of the anemic and nonanemic subjects, who were rated on conduct problems, personality disturbances, and inadequacy and/or immaturity. Conduct problems consistently surfaced as a trait of only the anemic subjects, not the controls. The latter two traits, personality disturbances and inadequacy or immaturity, produced no significant differences (27).

A longitudinal study was undertaken using sixty-one full-term infants as the sample. At six to eighteen months of age, thirty-two of the infants were anemic. (Hemoglobin ranged from 6.1 to 9.5 gm./ 100 ml. of blood.) When they were six to seven years old, all of the children were examined neurologically by persons who had no prior knowledge of some of these youngsters' early childhood anemia. The anemic group exhibited clumsiness in one-foot balancing, in tandem walking, and in repetitive hand or foot movements. The anemic children appeared less attentive and more hyperactive than did the nonanemic controls (27). The previous three studies that were discussed did not state whether anemia, iron deficiency alone, or general inadequate nutrition, of which low iron intake was only a part, was responsible for the behavioral changes (27).

A later study by Oski and Honig tested (23) the hypothesis that iron deficiency in infants and children is associated with behavioral alterations. Twenty-four anemic infants, ranging in age from nine to twenty-six months, served as the sample. The infants received psychological examinations prior to testing. Part of the group was treated with intravenous iron supplementation (to raise the hemoglobin to 12 gm./100 ml. of blood), and part received a saline placebo injection. The test was readministered in five to eight days. The treated group was found to be more alert, responsive, and adept in tests of motor coordinations. The findings of Oski and Honig support their original hypothesis (23). The iron deficiency, rather than the anemia (as a longer period of time is needed to overcome the anemia), rapidly reversed the behavioral abnormalities that appeared in the infants. Further studies must be conducted to demonstrate whether behavioral deviations are correctable after long-standing iron deficiency (23).

> If a child withdraws from his environment as a result of iron deficiency, he fails to learn. By missing one step in the learning process, he is less equipped to learn the next. Prolonged iron deficiency, like chronic undernutrition, could irreparably impair intellectual development, even if neurological structures remain essentially intact. (28:23)

Motor Sensory

Studies of rats by Rein (8) and Altman (2) and a later study of cats by Altman (2) concur that sensory-motor feedback is of utmost importance in the development of animal behavior patterns. Experimentation by Hoorweg and Stanfield (1) shows agreement with those findings. The sample in the study consisted of three groups of Ugandan children from the same tribe. At varying ages in early childhood, the three groups were admitted to the hospital for the treatment of severe protein-calorie malnutrition. When they reached adolescence (ranging from eleven to seventeen years of age), the groups were compared with a control group that had not experienced malnutrition. The three malnourished groups fell behind the control groups in anthropometric measurements, tests of intelligence, and tests of motor abilities. The degree of malnutrition determined the degree of insufficiency. Reasoning and spatial abilities were most affected. Rote learning and memory were moderately affected, and language seemed least affected, if at all (10).

The following year, 1977, Dasen and others (7) published the results of a longitudinal study that had been undertaken to measure the possible effects of moderate malnutrition on sensory-motor intelligence and the resultant effect on cognitive skills. Baoulé infants (Ivory Coast) were used as the sample group of moderately malnourished subjects and after repeated testing, the results showed that the areas of behavior most affected by moderate undernutrition were decreased exploration of environment and decreased active experimentation (7).

Change Resulting from Improved Nutrition

Several studies show that food supplement programs improved the subjects' health and behavior.

Iowa Breakfast Study (1)

The classic example of behavioral changes due to food intervention is the Iowa Breakfast Study. Following varying types of breakfasts, participants' performance and behavior were measured on a series of tests, which consisted of a simple reaction test, a choice reaction test, a neuromuscular tremor magnitude test, a maximum grip strength test, a grip strength endurance test, a maximum work-rate and/or a maximum work-output test, and lastly a test that measured the amount of oxygen required for a specified amount of work. As a result of the scores on these tests, the following conclusions were made concerning the relationship to behavior:

1. The omission of breakfast or coffee alone resulted in decreased efficiency in the late morning, as reflected in poorer physiologic performance and also in poorer attitude toward school work and poorer scholastic attainment.

2. A breakfast containing one-fourth of the daily calories and one-fourth the daily protein (animal or vegetable and animal mixed) was superior in maintaining late morning efficiency than less adequate or no breakfast plans (1).

Mexican Study (5)

Food supplements were given to the children of rural Mexican families who were carefully chosen as representative of the community. Later, the growth rates were compared with those of their previously measured siblings. There was an increase in the growth rate of the children who received food supplements. Also noted was an increase in physical strength, attentiveness, independence, and performance on behavioral tests. The siblings who were given supplements played more with their toys, explored their environment, and interacted with adults more often (5).

National School Breakfast Program (35)

The National School Breakfast Program has done much to relieve the symptoms of hunger and subsequently has improved the behavior of school children. The direct observation of personnel dealing with the changed behavior of these children is most impressive. Comments are as follows:

> "Now there are no discipline problems in the morning. Two years ago, before the breakfast program, it was very noisy in the morning and a generally bad atmosphere." (California elementary principal) (35:45)

> "I don't get into fights on the playground before school too much anymore; everyone wants to eat and not have trouble." (Kansas school student) (35:35)

The effectiveness of the program was rated by the New York school personnel, namely, administrators, teachers, school staff, and food service employees. The data in Table 12 reveal their evaluation. Positive results were recorded in the areas of alertness, attentiveness, improved health, improved nutrition, decreased discipline problems, and decreased tardiness (35).

Table 12

Evaluation of the New York School Breakfast Program

	Positive response	Responses indicate no change
Students more alert and attentive	416	27
Improved health and nutrition	127	14
Fewer disciplinary problems	54	5
Less tardiness	33	2

Source: (35)

Evidence of Change in Achievement

Researchers have sought to explore the relationship between malnutrition and the development of intellect and learning (3). Results are less than concrete because of the previously discussed factors leading to changes in both behavior and achievement. Most authorities believe it is not possible today to develop culture-free tests of ability, nor will it be possible in the future to isolate the specific effects of malnutrition upon intellectual competence (36).

Change Resulting from Food Deprivation

The following studies describe the intellectual and physical changes that occur in children because of food deprivation.

Protein-Calorie Deficiency

Substantial evidence supports the findings of negative effects of malnutrition on physical growth and mental development, particularly during the prenatal and postnatal periods (25). Increased concern exists that insufficient nutrition not only restricts skeletal growth but also adversely affects the central nervous system, thus depressing intellectual capacities of children (25). Both chronic and severe clinical malnutrition in childhood, along with social factors, is associated with subsequent growth retardation and poor intellectual and scholastic performance (36).

Intelligence is highly correlated with school achievement. As reported by Smith, a study of malnourished Mexican school children measured their scholastic achievement. Results indicated premature birth weights were significantly associated with low performance on school-administered tests and perceptual motor functioning (32).

Several significant research studies, some in retrospective studies and others in longitudinal studies, have attempted to quantify the relationship between food deprivation and intellectual achievement. A study that investigated the relationship of growth to intellectual achievement among malnourished Guatemalan rural Indian children was completed. Findings indicated a correlation between lack of physical growth and a lack of achievement. However, this study, as did others which were similar (6, 33), inferred malnutrition from height differences rather than dietary patterns (3).

Cravioto, Hambraeus, and Vahlquist (6) reported the return of intellectual competence among malnourished children hospitalized in Mexico for malnutrition. The findings showed that recovery was less complete for the children hospitalized before six months of age than for the older children (3). Children admitted later in life with the same degree of malnutrition recovered after prolonged rehabilitation (38). This result led to the belief that the earliest stage of infancy is the most critical in brain development (3). A study of Serbian children with a history of marasmus during the first year of life revealed they had lower I.Q. scores than Serbian children in general. Again, the largest I.Q. deficits occurred when the subjects were the youngest at the time of nutritional deprivation (38).

However, the Jamaican study by Hertzig and others (9) does not support this belief. Children malnourished during the first two years of life were found to have equivalent I.Q. depressions, regardless of the specific time malnutrition developed (3). Low I.Q. was attributed more to social background than to malnutrition (29). Furthermore, intellectual functioning at school age was studied in boys who were severely malnourished during the first two years of life. Findings showed that these children had lower levels of intelligence at school age than their siblings and classmates (9).

Other studies by the United States (4) and Chile (20) agree that severe malnutrition early in life tends to depress intellectual achievement at later ages (3). There is suggestive evidence that the longer or more severe the malnutrition, the more serious the effect on intellectual development. In longitudinal studies, there was a tendency for all performance differences in the tests to decrease with increasing age, especially in those studies extending up to fifteen years (18).

The findings of studies of infants and preschool age children showed significantly diminished performance in the malnourished groups. In contrast, the same children at school age showed that at least 50 percent did not demonstrate significant intellectual deficits compared with the adequately nourished (18).

Iron Deficiency

In addition to malnutrition derived from deprivation of calories, iron deficiency shows evidence of decreased achievement levels. During a hematologic survey in a junior high school, the relationship between the presence of anemia and school performance was examined. Scores on the Iowa Tests of Basic Skills were significantly lower in anemic, presumably iron-deficient, students than in their nonanemic counterparts. Whether the poor performance was a consequence of the iron deficiency alone or the result of a general nutritional inadequacy is unclear (37).

A similar study, using the Bayley Scales of Infant Development as an index, was also performed on iron-deficient infants. After the infants were identified, treatment to raise the hemoglobin level was administered. The results suggest that the abnormalities in performance are rapidly reversible if they are treated during the first two years of life. The correction of long-term iron deficiency during later life has not been demonstrated (23). Pollitt also concludes, through studies, that iron-deficient children showed decreased over-all intellectual performance (27).

Change Resulting from Improved Nutrition (29)

Results of studies indicate that improved nutrition increases a child's intellectual performance.

Environmental Supplementation

Exposure to an adequate nutritional environment improves performance in children. One study involving severely malnourished babies with cystic fibrosis, a disease which leads to failure of intestinal absorption, showed a failure of these children to grow even when their families fed them well. After treatment in a favorable social environment, these children showed retardation in intellectual performance through the first five years of life; after this stage the retardation gradually disappeared (33).

Before they were adopted by American parents, a group of Korean girls was divided into three categories: malnourished, marginally nourished, and well nourished. The objective of the investigation was to see whether enriching the environment of previously malnourished children might result in improved development. The study followed the girls over the years; and the results showed that when children are reared in a middle-class environment, they can catch up to levels of growth and achievement which are normal for well-nourished children. By contrast, within the sub-divided group, the well-nourished portion achieved an I.Q. significantly higher than the marginally nourished and malnourished (38).

Conclusions by Chase and Martin (4) in their work done in Denver, Colorado, indicate that those children who were treated during the first four months of life had essentially normal development quotients after three and one-half years. But the children who were treated between four and twelve months of age had significantly lower development quotients (4).

Even after adequate development of the brain structure has been assured, nutritional deficiencies can cause impaired functioning, which interferes with learning and performance. Thiamine deprivation leads to anxiety, irritability, depression, and increasd sensitivity to noise and pain. Insufficient quantities of nicotinic acid cause listlessness, apprehension and depression, while lack of adequate amounts of vitamin B12, iodine, and iron cause other changes in the body which impair normal functioning. Environmental factors that accompany malnutrition in a synergistic manner also affect mental ability and total performance (16).

School Food Programs

There is scanty research concerning the relationships between participation in the school food programs and school performance (15). In East Africa, Tanzanian children who received a school snack had better growth and improved hemoglobin levels than the control children. Subjective evidence also revealed that the children receiving the snacks had improved levels of concentration, alertness, and school performance (15).

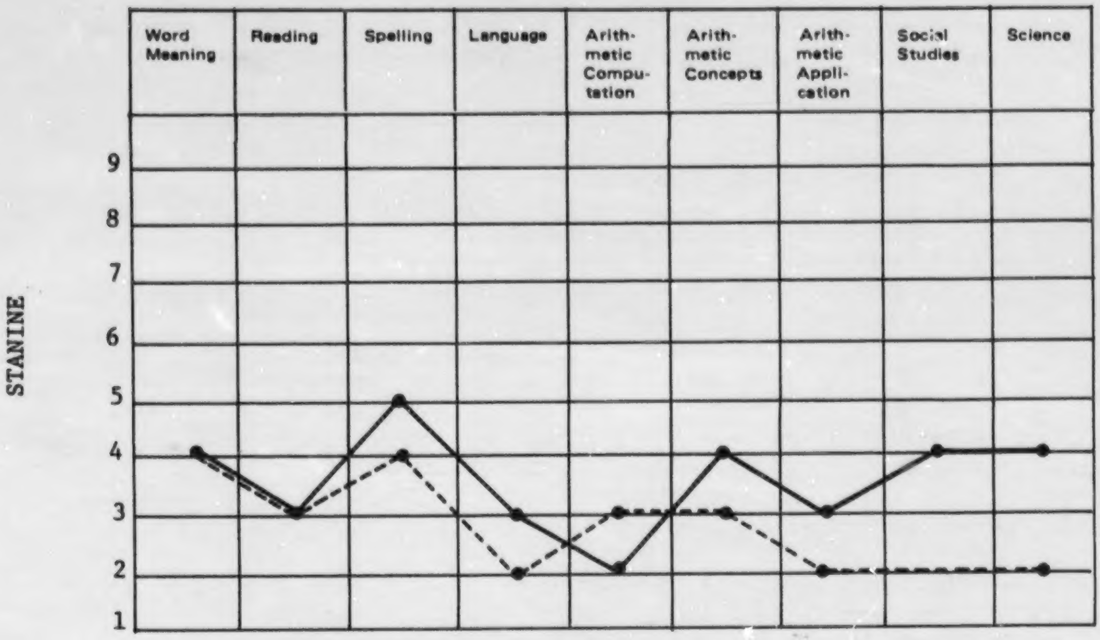
Comments that teachers and school representatives made about those children who participated in the school breakfast program revealed improved student achievement. Some of the comments follow:

> "Teachers who initially fought the program were surprised and impressed with the improved classroom behavior, longer attention spans and better performance in classwork." (Ohio food service director) (35:34)
>
> "We have noticed a definite improvement in attitude and performance." (Principal in California) (35:41)
>
> "Where the breakfast was served to needy children, teachers reported improved attendance, better attention in class, less drowsiness due to hunger, and improved performance and marks as a result of this program." (Ohio school superintendent) (35:6)

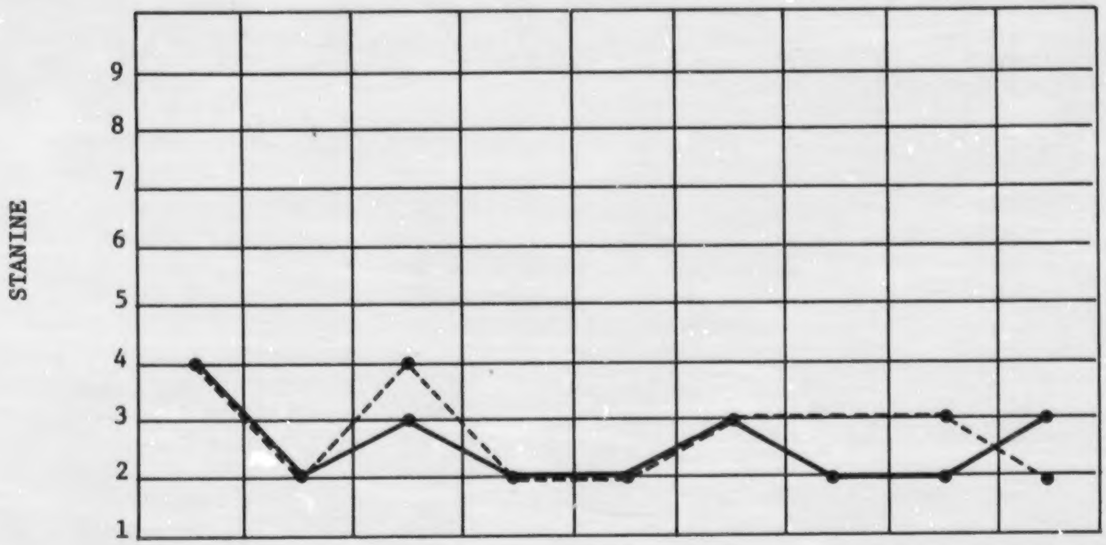
These comments do not prove that the breakfast programs are solely responsible for improved learning and achievement, but they are indications of positive effects (35).

A nutrition achievement study in the Tennessee schools attempted to measure any correlation between participants in the school lunch program and improved achievement scores. The subjects were students who did not participate in the school lunch program in 1967 but did partake in 1968. The control subjects did not participate in either year (Figure 13). The resulting scores are not positive proof that the school lunch program caused a rise in academic achievement, but suggest that proper nutrition is a major contributing factor (34).

School Lunch Participants



Control Group



1968 ________

1967 _ _ _ _

Figure 13

Tennessee
Nutrition-Achievement Study 1967-1968

Source: (34)

Conclusions

Results of animal and human studies suggest that severe malnutrition in infancy causes central nervous system damage which then in turn causes mental retardation. This statement is in fact an oversimplification of the problem. A more complex conceptualization is needed which takes into account biologic and social variables that may influence the child's intellectual functioning and development over his lifespan, including the period of fetal growth and the neonatal period. Data in Tables 13 to 17 show the different human studies performed and the specific results from each study concerning behavior and achievement.

While most studies recognize the benefits of proper nutrition, it is impossible to separate this causative factor from all the other factors (social, genetic, and environmental) which influence the mental development of the child. W. A. Ketcham listed four main factors which determine individual differences in school performance and the percentages attributable for each:

1. Physical growth and physical and mental maturation, 70 percent

2. Socioeconomic background of the family, 5 percent

3. Perturbations including damage, deprivation, and mismanagement, 15 percent

4. Curricula and teaching methods, 10 percent (12)

The data in Figure 14 demonstrate some of the possible factors which influence mental development and point again to the complexity of the problem of malnutrition and its relationship to health, achievement, and behavior.

Table 13

Summary of Behavioral Studies of Children with Nutritional Marasmus

Study	Experimental subjects					
	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Brockman and Ricciuti	N = 20 Diagnosed as marasmus, body weight less than 50% of expected for age, free of apparent edema; normal serum albumin	Mean of 10 younger children: 9.2 mos. Mean of 10 older children: 16.2 mos.	N = 19 Matched for sex and age with patients; attended regularly day care centers of Lima slums, body length at or above 10th percentile of Boston growth curves	Experimental mean of 10 younger children: 17.9 mos; mean of 10 older children: 34.9 mos. Controls: mean of 9 younger children: 18.7 mos. mean of 10 older children: 33.8 mos.	Categorization behavior through 10 sorting of 8 objects each	Average test scores 24 mos. 24 mos. Exp. 9.2 20.0 Cont.21.0 40.0
Cabak and Najdanvic	N = 36 Marasmus: slight edema present in a few; 27% or below the correct weight for their age; no TB or CNS diseases	4-24 mos.; most were below 12 mos.		7-14 yrs.	Adaptation of the Binet-Simon Scale: IQ	Mean IQ 88; IQ frequency distribution: N IQ range 18 91-110 12 71-90 6 70 Mean IQs of children from two nearby communities; 101 and 109

Table 13 (Continued)

Summary of Behavioral Studies of Children with Nutritional Marasmus

Study	Ex[illegible]rimental subjects		Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
	Numb[illegible]nd descr[illegible]n of n[illegible] tiona[illegible] condit[illegible]	Age at time of hospital admission				
McLaren et al.	N = 30 Groups Us and S same children as in Yakin and McLaren (88) N = 15 Group U: moderately undernourished for ca. 3 yr. no hospitalization		N = 15 Healthy; matched for age and socioeconomic status N = 14 Healthy sibs of group S N = 15 Healthy sibs of group US N = 15 Healthy sibs of group U	Means: Group Us 42 mos. Group S 49 mos.	Stanford-Binet Intelligence Scale: IQ	Mean IQ: Group S 78.9 Sibs 92.2 Group Us 86.1 Sibs 94.9 Group U 87.7 Sibs 94.9 Control 98.7
Monckeberg	N = 14 Severe marasmic malnutrition	3-11 mos. (mean 6.2 mos.)		3-6 yrs.	"Binet Method" Intelligence Quotient	Mean IQ 62; no child with IQ above 76
Pollitt and Granoff	N = 19 Weight deficit of 40% or more for age; free from edema; normal serum albumin	6-8 mos. (mean 16 mos.)	N = 28 Sibs of patients; no history of malnutrition	Experimental: 11-32 mos. (mean 22 mos.) Control: 3-30 mos. (mean 9 mos.)	Bayley Scales of mental and motor development: mental DQ, motor DQ	Results reported on mean sigma scores Mental scale Exp: -4.04 Cont: -0.70 Motor scale Exp: -3.76 Cont: -5.50

Table 13 (Continued)

Summary of Behavioral Studies of Children with Nutritional Marasmus

Study	Experimental subjects		Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
	Number and description of nutritional condition	Age at time of hospital admission				
Yaktin and McLaren	N = 30 Acute, severe marasmus, 53% of 50th percentile Boston standard for weight	2.5-16 mos. (mean 8 mos)		Tested on admission and subsequently every 2 weeks for 14 weeks	Griffiths Mental Development Scale: DQ	Mean DQ on admission: stimulated 51, unstimulated 46. DQ at end of 14 weeks: stimulated 79, unstimulated 68
Source: 26						

Table 14

Summary of Behavioral Studies of Children with Kwashiorkor

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Barreda-Moncada	N = 60 Growth retardation; skin change; edema; psychic changes, hair changes, liver hypertrophy	15.7-71.0 mos.		60 cases tested 7-12 wks. after hospital admission, 75% of cases evaluated 2 yrs. later	Gesell Schedules: DQ	After 7-12 wks. of hospitalization DQ 65 (expected 100) Marked retardation in language (DQ 50-60); most improvement in motor development (DQ 74); after 2 yrs. DQ 61-88
Birch et al	N = 37 Edema, skin lesions, evidence of fewer dietary proteins than calories	6-30 mos.	N = 37 Healthy sibs	Experimental: 5-13 years Control: 5-12 yrs.	Wechsler Intelligence Scale for Children: IQ	Mean IQ index 68.5 Control 81.5
Champakam et al	N = 19 "Classic signs of kwashiorkor"	18-36 mos. (mean 27.1 mos.)	N = 50 Control matched for: age, sex, religion, caste, SES, family size	Experimental: 8-11 years (mean 9.2 years) Control: 8-11 yrs. (mean 10.1 years)	Intelligence test; subscales in four areas: memory, perception, abstraction, verbal.	Performance of experimental Ss on IQ test expressed as % of the controls Age (year) 8-9 9-10 10-11

Table 14 (Continued)

Summary of Behavioral Studies of Children with Kwashiorkor

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
					Intersensory development: visual-haptic, haptic-kinesthetic	Mean % 31.30 54.45 52.44 Greatest difference in abstract and perceptual abilities. Intersensory organization poorer in experimentals than controls. Difference between groups decreased as age increased
Cravioto and Robles	N = 20 Third-degree protein-calorie malnutrition, presence of edema	6-30 mos.		1 yr. after hospitalization	Gesell Schedules: DQ	Younger (<6 mos.): Ss performance decreased with increased hospitalization Older Ss (>6 mos.): Performance improved to nearly normal with hospitalization

Table 14 (Continued)

Summary of Behavioral Studies of Children with Kwashiorkor

Study	Experimental subjects					
	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Evans et al	N = 40 Documented history of kwashiorkor	10-48 mos. (mean 19.6 mos.)	N = 40 Sibs of experimental Ss matched for age	Experimental: mean 11.5 years. Control: mean 11 yrs.	New S. African Individual Scale: Intelligence score Goodenough-Harris Drawing Test: drawing score	Intelligence score Exp. 77 Cont. 78 Drawing score Exp. 76 Cont. 80 Av. normal 83
Gerber and Dean	N = 25 Conformed to description of kwashiorkor	23 Ss: 1-3 years		Tested during hospitalization	Gesell Developmental Schedules	All Ss scored moderately at hospital release
Source: 26						

Table 15

Summary of Behavioral Studies Dealing with Mixed or Undifferentiated Protein-Calorie Malnutrition

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Chase and Martin	N = 19 Diagnosed as undernourished weight-age-height-age ratio 1	1.5-10.0 mos. (2 Ss readmitted at 18 and 24 mos.)	N = 19 Matched for: birth date, place of birth, weight, sex, race	Experimental: 24-41 mos. Control: 24-41 mos.	Yale Revised Developmental Examination: DQ	Mean DQ: Index 82, control 99 Lowest score of index group was in language area; index children admitted >4 mos. of age show lower scores than those admitted <4 mos.
Cravioto and DeLicardie	N = 22 Clinical Kwashiorkor and marasmus (10 treated at home, 12 hospitalized)	4-53 mos.	Healthy; matched at birth for gestational age, body length, and weight	Experimental and control: birth to 58 mos.	Gesell Developmental Schedule language development score Bipolar concept test: bipolar concept score Bettye Caldwell Inventory: home stimulation score	Index had lower language developmental score than controls from ca. 1 to 3 yrs. Index had lower bipolar concept scores from 26 to 58 mos. Index scored lower on home stimulation scores at 6 and 48 mos.

Table 15 (Continued)

Summary of Behavioral Studies Dealing with Mixed or Undifferentiated Protein-Calorie Malnutrition

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
DeLicardie and Cravioto	N = 14 Subset of above children	4-38 mos.	Group CB: Subset of children in above group (ref.21) Group CIQS: Children matched at age 5 for IQ and sex	Experimental and control: 5 yrs.	Adaptation of Wechsler Preschool and Primary Scale Behavioral response to cognitive demands	Index gave smaller proportion of work responses to cognitive demands than either group CB or CIQS Index gave fewer verbal responses than CB and responded in different style
Fisher et al	N = 72 Kwashiorkor 44 Marasmus 12 Marasmic-kwashiorikor 13 Unclassified 3	Mean 1-6 yrs.	N = 143	Index: 9.6-16.5 yrs. Control: 10.2-15.2 yrs.	Derivation of Koh's Blocks and a test requiring completion of two matrices	Experimental group did "consistently" poorer than control; no statistics available
Hertzig et al	N = 71 Diagnosed as having marasmus, kwashiorkor or marasmic-kwashiorkor	<2 yrs.	N = 71 Classmates of same sex and similar age N = 38 Healthy, male sibs	Experimental: 5 yrs. 11 mos. to 10 yrs. Sibs: 6 yrs. to 12 yrs. 11 mos. Control: 5 yrs. to 10 yrs. 11 mos.	Wechsler Intelligence Scale for children: IQ	Mean IQ: Index 57.7 Sibs 61.8 Cont. 66.0

Table 15 (Continued)

Summary of Behavioral Studies Dealing with Mixed or Undifferentiated Protein-Calorie Malnutrition

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Klein et al	N = 8 Severely malnourished		N = 8 Adequately nourished	Experimental: 14 mos.	Cardiac Habituation	Index required more trials to respond to a novel auditory stimulus
	N = 17 Malnourished		N = 11 Adequately nourished	Experimental: 5-6 yrs.	Eleven psychological tests	Index performed more poorly on tests requiring high level of attention
Richardson	N = 71 Same children as Hertzig et al		Control group not investigated		Home interviews with mothers or guardians: socioeconomic and environmental data	Index had poorer housing and more disadvantaged caretaker, less schooling, and higher sibling mortality
Richardson et al	Same index group as above except N reduced to 62		Same as above plus sib control group (N = 31)	Same as above	Wide Range Achievement Test: reading, spelling, arithmetic	Index averaged 7-9 points lower on WRAT than controls; index and sib obtain nearly identical scores
					Teacher evaluation	Teacher evaluation lower for index than controls, no difference between sibs and their comparison groups

Table 15 (Continued)

Summary of Behavioral Studies Dealing with Mixed or Undifferentiated Protein-Calorie Malnutrition

Study	Experimental subjects		Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
	Number and description of nutritional condition	Age at time of hospital admission				
					Median school grade	Index had lower median grade than controls; no differences between sibs and their comparisons
Richardson et al	Same as above		Healthy; same sex sibs Classmates of same sex and similar age		Home interviews with mothers or guardians, behavioral data	Index Ss were less liked by sibs, more unhappy in school, and behaved more immaturely, clumsily and unsocially than controls; sibs did not differ from their comparisons

Source: (26)

Table 16

Summary of Behavioral Studies Dealing with Malnutrition
Secondary to Neonatal Disorders

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Berglund and Rabo	N = 202 Hypertrophic pyloric stenosis; divided into four groups of severely malnourished based on weight and duration				Intelligence test used at induction for military service: score Adaptation test: score	No relationship found between degree of severity and level of test scores
Ellis and Hill	N = 22 Diagnosis of cystic fibrosis in infancy; 19 cases had 20-40% weight deficit during first year, 3 cases had 40% weight deficit during first year		N = 16 Diagnosis of cystic fibrosis in infancy; weight deficit <20% during first year of life	Index and and control: 7-19 yrs.	Wechsler Intelligence Scale for Children: IQ Wide Range Achievement Test: score Parental interview: socioeconomic data	Full-scale WISC IQ and WRAT scores; no significant differences between groups No differences between groups on socioeconomic data

Table 16 (Continued)

Summary of Behavioral Studies Dealing with Malnutrition Secondary to Neonatal Disorders

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Klein et al	N = 50 Hypertrophic pyloric stenosis at 0-3 mos.; no neurological damage; divided into high (21-42%), moderate (11-20%), and low (0-10%) severity of starvation based on weight at admission	1-60 days	N = 44 Siblings nearest in age N = 50 Matched for age, sex, and father's education	Experimental: 5-14 yrs. (mean 9 yr. 2 mo) Sib: 5-15 yrs. (mean 10 yr. 1 mo)	Numerous tests including: Peabody Picture Vocabulary Test: score; Wechsler Intelligence Scale for children vocabulary score, coding score, digest span Raven Progressive Matrices: score	Lowest weight deficit associated with lower test scores Index has lowest scores on coding, digest span No consistent differences between groups on PPVT or Raven
					Parental estimate development scale	Significant correlation between severity of starvation and parental estimate development scale.
					Ottawa school behavior checklist: score	Onset between 21 and 30 days related to more school problems measured by OSBCL

Table 16 (Continued)

Summary of Behavioral Studies Dealing with Malnutrition Secondary to Neonatal Disorders

	Experimental subjects					
Study	Number and description of nutritional condition	Age at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Lloyd-Still et al	N = 41 34 had cystic fibrosis, 11 meconium ileus, 4 protracted diarrhea, 3 ileal atresia; weight 3rd percentile for first 4 mos.; edema, neurological abnormalities, and biochemical disturbances present in some cases		N = 41 Siblings not malnourished	Index: 2-21 yrs. Control: 2-19 yrs.	18-72 mos.: Merrill-Palmer Scale: score 5-15 yrs.: Wechster Intelligence Scale for children: IQ 14-21 yrs: Wechster Adult Intelligence Scale: IQ	Significant difference index 40th percentile, control 70th percentile WISC + WAIS IQ: no significant differences
					5-15 yrs.: Lincoln-Oseretsky	No significant differences
					Vineland Scale of Social Maturity	No significant differences
Valman	N = 20 Group 1 (N = 7) had resection of ileum; group 3 (N = 13) had cystic fibrosis of pancreas		N = 26 A class of school-children	Index: group 1, 5-14 yrs.; group 3, 6-12 yrs.; Control: 6.5-7 yrs.	Goodenough-Harris drawing test: score Teacher assessment for group 1	Group 1, 106.3; Group 3, 98.4; Control 99.9 All progressing normally

Table 17

Summary of Mild-to-Moderate Studies: Field Studies

	Experimental subjects				
Study	Number and description of nutritional condition	Number and description of control Ss (if any)	Age of experimental and control Ss at elevation	Test used and type of measure obtained	Results
Cravioto et al	N = 143 Upper and lower height quartiles of presumably mildly to moderately malnourished children living in rural environment	N = 120 Upper and lower height quartiles of well-nourished children living in upper-class urban environments	6-11 yrs.	Test of intersensory organization visual kinesthetic, visual-haptic kinesthetic total extra scores	Urban group had fewer errors on all tests than rural group, total multiplied by errors score of rural lower quartile higher than upper quartile. For urban group few differences seen in lower vs. upper quartiles. Highest multiplied by error score for both urban and rural was in youngest age group (6 yrs) no statistical significance provided
Klein et al			3-6 yrs.	Language facility score Short Term Memory for Numbers score Preceptual Analysis score	Nutritional and social variables are corrected to psychological test performance. Magnitude of correlation of social or nutrition variables varies with type of test and child's sex
Winick et al	N = 41 Group 1 severely malnourished	N = 47 Height and weight 25th percentile	7-15 yrs.	Information on IQ scores and achievement scores	Mean IQ Group I 103.46 Group II 104.81 Controls 113.4

Table 17 (Continued)

Summary of Mild-to-Moderate Studies: Field Studies

Study	Experimental subjects		Age of experimental and control Ss at elevation	Test used and type of measure obtained	Results
	Number and description of nutritional condition	Number and description of control Ss (if any)			
	height and weight 3rd percentile N = 51 Group 2 moderately malnourished height and weight 3rd-25th percentile			obtained	multiplied by percentile achievement scores Group I 5.07 Group II 5.79 Controls 6.48

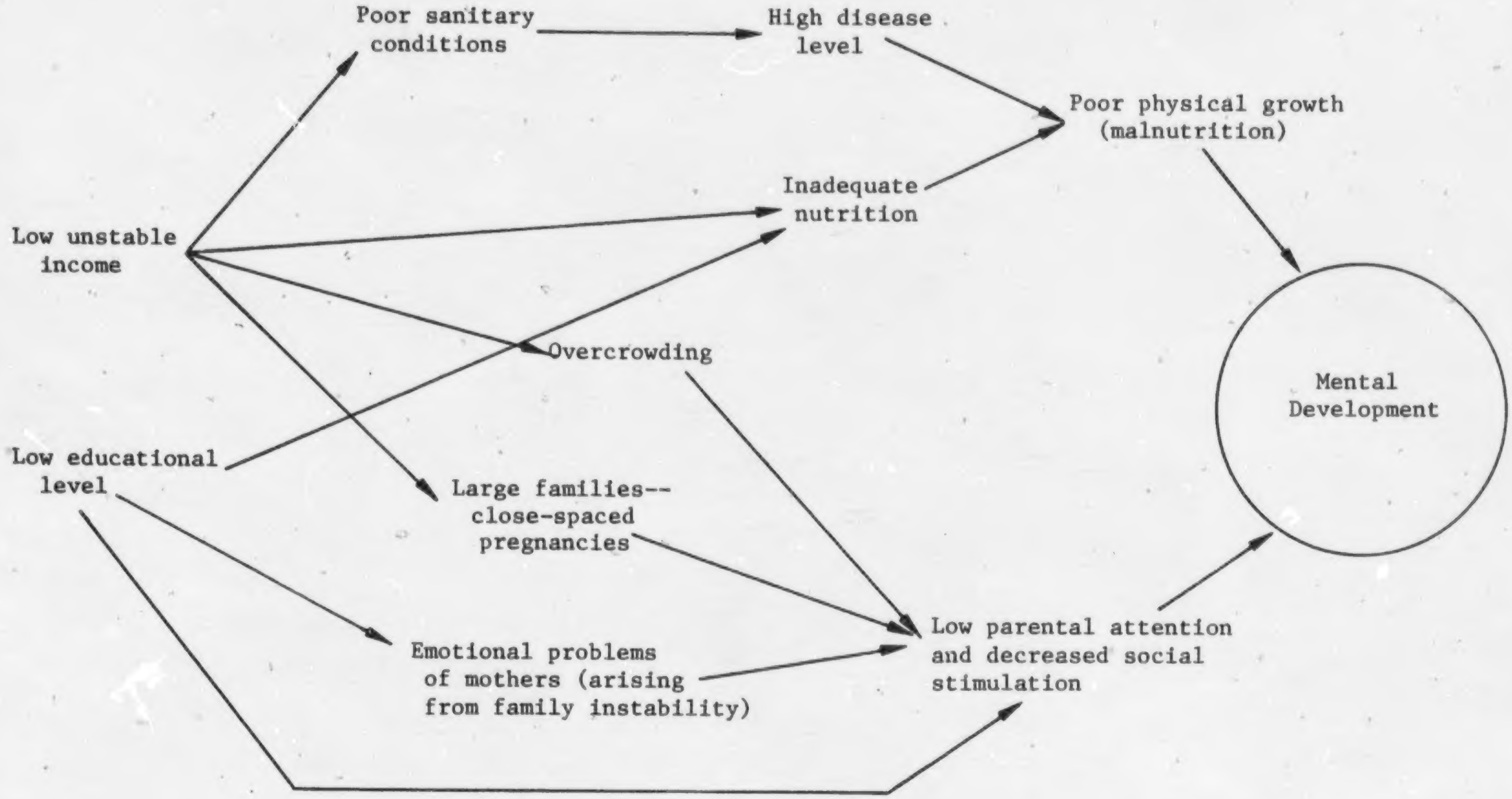

Poor sanitary conditions
High disease level
Poor physical growth (malnutrition)
Inadequate nutrition
Low unstable income
Overcrowding
Mental Development
Low educational level
Large families--close-spaced pregnancies
Emotional problems of mothers (arising from family instability)
Low parental attention and decreased social stimulation

Figure 14

Possible Factors Affecting Mental Development

Source: (19)

Bibliography

1. A Complete Summary of the Iowa Breakfast Study. Chicago, Ill.: Cereal Institute, Inc., September 1962, reprinted January 1976.

2. Altman, J. "Effects of Early Experience on Brain Morphology," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts: The MIT Press, 1968.

3. Birch, R. G. "Malnutrition, Learning, and Intelligence," American Journal of Public Health, 62(6) (June 1972), 773-784.

4. Chase, H. P., and H. P. Martin. "Undernutrition and Child Development," The New England Journal of Medicine, 282(17) (April 23, 1970), 933-939.

5. Chavez, A., C. Martinez, and T. Yaschine. "The Importance of Nutrition and Stimulation on Child Mental and Social Development," Early Malnutrition and Mental Development. Eds. J. Cravioto, L. Hambraeus, and B. Vahlquist. Sweden: Almqvist and Wiksell, 1974.

6. Cravioto, J., L. Hambraeus, and B. Vahlquist, eds. Early Malnutrition and Mental Development. Sweden: Almqvist and Wiksell, 1974.

7. Dasen, P. R., and others. "Early Moderate Malnutrition and the Development of Sensori-Motor Intelligence," Journal of Tropical Pediatrics and Environmental Child Health, 23(3) (June 1977), 146-157.

8. Hein, A. "Labile Sensorimotor Coordination," Malnutrition, Learning, and Behavior. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts: The MIT Press, 1968.

9. Hertzig, M. E., and others. "Intellectual Levels of School Children Severely Malnourished During the First Two Years of Life," Pediatrics, 49(6) (June 1972), 814-824.

10. Hoorweg, J., and J. P. Stanfield. "The Effects of Protein Energy Malnutrition in Early Childhood on Intellectual and Motor Abilities in Later Childhood and Adolescence," Developmental Medicine and Child Neurology, 18(3) (June 1976), 330-350.

11. Kallen, D. J., ed. Nutrition, Development and Social Behavior. U. S. Public Health Service, DME Publication No. (NIH) 73-242, 1973.

12. Ketcham, W. A. "Problems of Measuring School Performance," Malnutrition, Learning, and Behavior. Eds. N. E. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts: The MIT Press, 1968.

13. Klein, R. E., J. Habicht, and C. Yarbrough. "Some Methodological Problems in Field Studies of Nutrition and Intelligence," Nutrition, Development and Social Behavior. Ed. D. J. Kallen. U. S. Public Health Service, DHEW Publication No. (NIH) 73-242, 1973.

Bibliography (Continued)

14. Latham, M. C. "Protein-Calorie Malnutrition in Chilren and Its Relation to Psychological Development and Behavior," *Physiological Reviews*, 54(3) (July 1974), 541-565.

15. Latham, M. C., and F. Cobos. "The Effects of Malnutrition on Intellectual Development and Learning," *American Journal of Public Health*, 61(7) (July 1972), 1307-1324.

16. Leverton, R. M. "Facts and Fallacies About Nutrition and Learning." Washington, D. C.: U. S. Department of Agriculture, 1969. (Mimeographed.)

17. Levitsky, D. A., and R. R. Barnes. "Malnutrition and Animal Behavior," *Nutrition, Development and Social Behavior*. Ed. D. J. Kallen. U. S. Public Health Service, DHEW Publication No. (NIH) 73-242, 1973.

18. Lloyd-Still, J. D. "Clinical Studies on the Effects of Malnutrition During Infancy on Subsequent Physical and Intellectual Development," *Malnutrition and Intellectual Development*. Ed. J. D. Lloyd-Still. Massachusetts: Publishing Sciences Group, Inc., 1976.

19. "Malnutrition and Mental Development," *WHO Chronicle*, 28 (1974), 95-102.

20. Manckeberg, F. "Effects of Early Marasmic Malnutrition on Subsequent Physical and Psychological Development," *Malnutrition, Learning, and Behavior*. Eds. N. S. Scrimshaw, and J. E. Gordon. Cambridge, Massachusetts: The MIT Press, 1968.

21. Mora, J. O., and others. "Nutrition, Health, and Social Factors Related to Intellectual Performance," *World Review of Nutrition and Dietetics*. Ed. G. H. Bourne. Basel, Switzerland: S. Karger, 1974.

22. National Academy of Sciences, National Research Council. *The Relationship of Nutrition to Brain Development and Behavior*. Washington, D.C., June 1973.

23. Oski, F. A., and A. S. Honig. "The Effect of Therapy on the Developmental Scores of Iron-Deficient Infants," *The Journal of Pediatrics*, 92(1) (January 1978), 21-25.

24. Perkins, S. A. "Malnutrition: A Selected Review of Its Effects on the Learning and Behavior of Children," *International Journal of Early Childhood*, 5(2) (1977), 173-179.

25. Perkins, S. A. "Malnutrition and Mental Development," *Exceptional Child*, 43(7) (January 1977), 214-219.

26. Pollitt, E., and C. Thomson. "Protein-Calorie Malnutrition and Behavior: A View from Psychology," *Nutrition and the Brain*, Vol. 2. Eds. R. J. Wurtman and J. J. Wurtman. New York: Raven Press, 1977.

Bibliography (Continued)

27. Pollitt, E., and R. L. Leibel. "Iron Deficiency and Behavior," The Journal of Pediatrics, 88(3) (1976), 372-381.

28. Read, M. S. Malnutrition, Learning, and Behavior. U. S. Public Health Service, DHEW Publication No. (NIH) 76-1036, April 1976.

29. Richardson, S. A. "The Relation of Severe Malnutrition in Infancy to the Intelligence of School Children with Differing Life Histories," Pediatric Research, 10(1) (January 1976), 57-61.

30. Scrimshaw, N. S., and J. E. Gordon, eds. Malnutrition, Learning, and Behavior. Cambridge, Massachusetts: The MIT Press, 1968.

31. Shineour, E. A. The Malnourished Mind. Garden City, New York: Anchor Press - Doubleday, 1975.

32. Smith, N. B. "Child Nutrition in a Changing World," Childhood Education, 51 (January 1975), 142-145.

33. Stoch, M. B., and P. M. Smythe. "15-Year Developmental Study on Effects of Severe Undernutrition During Infancy on Subsequent Physical Growth and Intellectual Functioning," Archives of Disease in Childhood, 51(5) (May 1976), 327-336.

34. "Tennessee Nutrition-Achievement Study 1967-1968," School Lunch Journal, 23(1) (January 1969), 29.

35. The Food Research and Action Center. "If We Had Ham, We Could Have Ham and Eggs. . . If We Had Eggs." A Study of the National School Breakfast Program. Director, Ronald Pollack. New York: Gazette Press, Inc., 1972.

36. Tezard, J. "Early Malnutrition, Growth and Mental Development in Man," British Medical Bulletin, 30(2) (May 1974), 169-174.

37. Webb, T. E., and F. A. Oski. "Iron Deficiency Anemia and Scholastic Achievement in Young Adolescents," The Journal of Pediatrics, 82(5) (May 1973), 827-830.

38. Winick, M. Malnutrition and Brain Development. New York, London, and Toronto: Oxford University Press, 1976.

CHAPTER 13

Conclusions and Recommendations

To consolidate all the results of all the nutritional status studies performed in the United States, or even in the state of California, is impossible. Different techniques for gathering data, different methods of determining a nutrient lack, and different sample selections make integration of results impossible. Each study has its shortcomings. However, these studies, which represent extensive efforts to disseminate significant nutritional data to the public, are an excellent beginning in creating nutritional awareness. The investigations provide invaluable information upon which future research will be based.

These studies reveal overt manifestations of malnutrition in children: the prevalence of obesity, growth retardation, infectious disease, dental disease, and anemia. The studies also point to the disguised symptoms of malnutrition: apathy, listlessness, and lack of exploratory activity. No severe widespread malnutrition or severe widespread hunger in the United States was suggested by status evaluation. The most important consideration that became apparent was the need for continuation and expansion of status studies, emphasizing a need to adapt to each new demand of time.

The United States has, to a large extent, prevented or controlled the severe life-threatening diseases of infancy and early childhood. However, other serious diseases or conditions influenced by environmental factors remain as problems. Although severe malnutrition today is concentrated in the less developed countries, conditions of poverty, acute financial distress, and current inflation in the United States render many families unable to provide food to meet the nutrient needs of their children.

Proper nutrition alone does not lead to brighter, healthier children. Diet is just one of the many things which contribute to the proper environment necessary for the learning process to take place. There is an interaction between malnutrition and other environmental factors, especially social stimulation. The child's ultimate intellectual status is the result of this interaction.

Literature to support the fact that moderate malnutrition alone produces children who are intellectually stunted is nonexistent. It is true that early severe malnutrition can permanently affect brain growth and function, but in the United States moderate malnutrition and hunger are more prevalent and seem to interrupt the learning process by producing apathy, listlessness, and a lack of desire to attempt something new. If one step is missed in the learning process, the learning of the next becomes more difficult. This gap, in turn, could change the child's life and cripple his or her future potential.

The existence of malnutrition in any form illustrates the value of supplemental feeding for children, a practice which offers the continuity of nutritional health so that each child might reach his or her greatest physical and intellectual goals. A child's environment cannot always be controlled; however, all efforts must be made to rectify a child's nutritional deficiencies.

To advance the nutritional and health status of school children enabling them to reach their maximum intellectual and physical potential we recommend:

1. Review current methods employed in nutritional status studies, adopt time-proven methods, and eliminate the more questionable techniques. Incorporate the successes found in status studies from other countries with those practices currently used in the United States.

2. Provide general support so that experienced nutritionists can develop innovative, creative nutrition education programs for teachers, students, and food service workers. Require all teachers to take a basic course in nutrition.

3. Use the school facility as a base for teaching community nutrition to parents, students, and other interested parties to ensure continuity of nutrition education from the classroom to the home. Programs should be expanded to include prenatal nutrition and instruction in proper eating habits to improve dental health.

4. Incorporate the National Nutrition Guidelines into the school feeding programs as quickly as is practicable.

5. Involve students in menu planning, which emphasizes the selection of nutritious foods for meals and snacks, rather than foods that primarily contain empty calories. A properly trained nutritionist or dietitian should be the planner of menus. This person can serve as a liaison between the food service operation and the school and should develop nutrition education programs for the school. Food selections should be available for children who are obese, hyperactive, allergic, diabetic, or who must observe the dietary laws of their religion.

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APR. 22 . 1981